hypermotion

On the way to the Digital Mobility Split

How digitalization is changing our transport systems

White Paper

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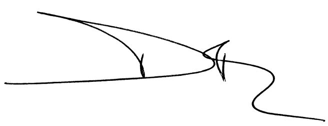
EDITORIAL

The great megatrends digitalization and decarbonization are changing mobility and logistics at a furious pace. What effect is this having on the established actors and what opportunities does it afford everyone involved? How can individual and intermodal logistics and mobility chains be created in smart cities and digital regions?

Answers to these questions are provided by Hypermotion, the second edition of which runs from 20 to 22 November 2018 in Frankfurt, to which I most warmly invite you. Here disruptive ideas and the intelligent networking of transport systems form the central focus. The event – an exciting mix of trade fair, tech talks, start-up pitches and conferences – offers numerous impulses and is the ideal platform to discuss and develop pioneering ideas and solutions together. Here established enterprises from the mobility, logistics and transport sectors meet mobility pioneers, start-ups and young entrepreneurs as well as experts and representatives from the worlds of science, politics and associations.

Be part of this dynamic intermodal network and help shape the future of mobility. I hope you enjoy this white paper and look forward to welcoming you to Hypermotion from 20 to 22 November 2018 in Frankfurt.



Detlef Braun
Member of the Executive Board of Messe Frankfurt

"The event – an exciting mix of trade fair, tech talks, start-up pitches and conferences – offers numerous impulses and is the ideal platform to discuss and develop pioneering ideas and solutions together."

We would like to thank the authors, Prof. Dr.-Ing. Michael Benz, Dr.-Ing. Stefan Walter and Daniel Jonas of Benz + Walter GmbH, for the realization of the white paper.

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SYNOPSIS

Logistics and mobility are facing the biggest and most disruptive changes that the sector and the companies operating in it have had to deal with in recent decades.

Digitalization and the widespread adoption of new technologies – such as autonomous driving and artificial intelligence in logistics and mobility – are steadily lowering the barriers to market entry and redefining customer expectations. Consumers in the digital age are accustomed to an *immersive* purchasing experience and fast delivery times. They assemble their products in virtual reality, illuminate them from all angles and then expect them to be available immediately and reliably delivered – as quickly as possible. They are no longer willing to invest a great deal of time and effort in every decision but expect service providers to alleviate their 'paradox of choice' by picking out the offers that best suit them. This *hyperconsumption* mentality is increasingly being carried over into the fields of logistics and mobility. This makes the market for logistics and mobility services an increasingly powerful magnet for new ideas, start-ups and innovative offers. With an unfamiliar twist for market participants: incumbents no longer have to contend solely with the known competition but increasingly also with enterprises from outside the mobility sector as well as lateral thinkers and lateral entrants. This is not only true of the automobile industry but also of both local and long distance public transport.

The ultimate consequence is that mobility, logistics and traffic will attain a state of *hypermotion* in which all elements of the system (such as data, people, infrastructure and assets as well as flows of goods and finance) are in a state of continuous exchange and perpetual motion. The basis for coping with the new complexity that arises from this will be a network structure described in this white paper as the *Hypermotion Grid*. It is made up of seven core elements essential to the transformation of mobility, logistics and traffic into a *hypermotive* transport system that requires:

›› new data sources to be opened up and infrastructural components to be intelligently networked with one another and with vehicles *(Connectivity)*

›› the system itself to be closed and data democratized to create total transparency – and thus controllability *(Monitoring & Transparency)*

›› decisions to be taken and new services developed on the basis of data *(Data Analytics & Security)*

›› the system to be more sustainable and sensitive to the environment *(Sustainability)*

›› logistical systems not only to be networked in supply chains but also integrated into the daily lives of consumers, in both urban and rural areas *(Synchronized & Urban Logistics)*

- efficient use to be made of limited capacities and infrastructure in conurbations – from cycle tracks to functional broadband *(Smart & Digital Regions)*, and
- (across all modes of transport) everything everywhere to be available at all times – intermodal + multimodal + digital *(Hypermodality)*

The customer is therefore the centre of attention for logistics and mobility service providers, such *customer centricity* being a prerequisite of sustainable market success. The customer decides on the basis of availability and reliability and abstracts from the statistically verifiable modal split of the means of transport. Increasingly decisive to the selection not only of the personal *travel chain* but also of the preferred *ordering method* is credible information on the customer's own smartphone – i.e. the *Digital Mobility Split*.

This *white paper* aims to set out a vision of the logistics and mobility sector of the future and stimulate discussion of further possible future scenarios. In the innovative, interactive *Hypermotion trade fair*, Messe Frankfurt has created the requisite *marketplace and showcase for intelligent solutions* and the *efficient transfer of knowledge*. Hitherto strictly segregated for the most part according to their respective modes of transport, communities from the worlds of mobility, logistics, traffic, infrastructure and transport unite to form an *innovative network of shapers of the future* and *problem solvers for the intelligent transport systems of tomorrow – and the day after.*

How smart logistics and mobility will actually look is still up in the air – the subject of fascinated speculation. Hypermotion offers here a wealth of opportunities to participate in their shaping. What is certain is that the *digital disruption* we are seeing now will lose nothing of its momentum and the *transformation* will continue uninterrupted. None of this will happen overnight; there'll be no instant, radical transformation. But business, science and society – politics, administration, regions, cities and citizens – all have an opportunity to play an active role in shaping the future of locomotion, even if it means rethinking and significantly altering their own roles and positions.

Reason enough in times in digitalization to visit a trade fair and play an active part in shaping the transformation ahead. Reason enough, too, for a white paper detailing explicitly the structure of Hypermotion – both of the fair and the intellectual approach that underlies it.

1

CHANGE IS IN THE AIR

1.1 The metamorphosis of mobility and logistics

Autonomous vehicles, artificial intelligence and 3D printing – what was previously the stuff of science fiction is gradually spawning marketable solutions. We find ourselves in a time of continuous change and disruptive technologies that are radically altering the way humans act and communicate with one another, as well as with machines and enterprises. Mobility and logistics, too, are confronted with new challenges as a result of the upheaval; challenges for which there are no tried-and-tested solutions. The advent of these new technologies heralds a new era in locomotion. This era will be characterized by the need to adapt the current structure of logistics and mobility systems to changing consumer behaviour and the increasing influence of new technologies. [1]

One of the most conspicuous manifestations of this transition phase is the so-called 'peak car' (a.k.a. peak travel) phenomenon seen mainly in developed countries such as those of North America and Western Europe. The peak car phenomenon denotes the stagnation and in some areas decline in demand for automobile travel. With the car no longer perceived as the all-purpose means of overcoming geographic distances, monomodal locomotion is giving way to multimodal. Many studies have established changing perceptions of the car as a status symbol and as the all-purpose means of locomotion, usually coming to the same conclusion: people want to get reliably from A to B – but not necessarily in their own cars (see, for instance, [2-4]). The fact remains, however, that outside urban centres, the phenomenon has had little impact on traffic development or the sales figures reported by manufacturers. This is often explained in terms of deficient local public transport capacity or inadequate infrastructure for ecomobility (walking, cycling, public transport).

In the field of logistics, we are seeing increasing acceleration in the speed at which delivery chains serve the end customers, whose demand ever more frequently is for the goods ordered to be delivered quickly – ideally, at once – and to their current location. A survey of over 3,000 consumers from different geographic zones by *METAPACK* revealed that

- 96% of those asked preferred suppliers offering a personalized and fast delivery service; [5]
- among those questioned in Germany, 48% had at some time or other cancelled an order because they considered the delivery time unreasonably long – 52% because they found the cost of delivery too high.

That such a service can cost something despite all this is proven by the constantly increasing membership of premium services such as Amazon Prime, which promises delivery the next day and in some areas within a few hours. Already the number of user/customer accounts here has passed the 100 million mark.

Mobility and logistics must therefore meet these and many other new user expectations. Digitalization is seen primarily as preparing the way and providing an opportunity for such a change. But it is also feared in some quarters. With the constant lowering of market entry barriers and the enhanced attractiveness of the logistics and mobility sector resulting from changing consumer expectations, established enterprises are increasingly having to contend with new competition. Autonomous driving is already the new 'battlefield' in California's silicon valley [6], in China and on German testing grounds. The creation of new digital mobility services is another attractive area, with lucrative market opportunities for whomever ultimately sets the standard. In addition, between 2012 and 2015 alone, the number of logistics start-ups with an inaugural capitalization of more than 2.5 million US dollars has gone from 34 to 74, more than doubling. [7] Worldwide, there is a new logistic start-up every five days.[7]

This increases the danger that with the onward march of digitalization successful business models, some now established for decades, will become superfluous or be displaced by some cheaper, ubiquitous, digital solution. Specialized start-ups can threaten the business model of logistics 'full-range retailers' and integrators by cherry-picking individual highly lucrative tasks or markets, as the profits from these can then no longer be used to 'subsidize' the standard solutions in low-margin markets. The entry into the market of adequately financed start-ups often invalidates business axioms in sub-markets.

In the financial sector, for example, 'fintechs'[1] have long been feared and are constantly posing new challenges to the established banks by finding novel ways of meeting customer needs. Logistics and mobility enterprises must therefore steel themselves against this new, digital competition and make ready to accommodate the preferences of digital consumers, so as to avoid succumbing to the ravages of 'digital Darwinism'[2] .

1.2 Quo vadis, logistics and mobility?

Mobility and logistics are at a crossroads with hitherto unimagined consequences. Digital disruption has the potential to redefine utterly the tasks, positions and relevance of enterprises in these markets. This white paper will set out to examine more closely and elucidate these factors and the resulting need for change with a view to providing enterprises and organizations with support and inspiration for the design of future solutions. As a corollary, the determinative factors and elements for successful digital transport and logistics systems will be defined – and later, at the Hypermotion, discussed and demonstrated.

The elements and success factors for future traffic systems described in the following chapters represent the standpoints and perspectives of the authors and *creators of the Hypermotion* with regard to the topics under discussion. The purpose of this white paper is to present a vision of the logistics and mobility sector of the future and to stimulate discussion of possible future scenarios.[3]

This white paper is structured as follows: in the next chapter, the drivers and trail-blazers of the digital disruption of mobility and logistics are described and analysed in greater detail. The chapter ends with an itemization of success factors as well as the consequent design elements for traffic systems in the digital age. These are then defined and described comprehensively in the subsequent chapter. Next, core theses and potential of the enumerated success factors are explained and discussed so that these can be carried over to other challenges. Finally the central findings are summarized once again to highlight the areas where action is called for.

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1 The word 'fintechs' is a neologism formed by conflating 'financial services' and 'technology'. It denotes companies that use (new) technologies to improve financial services.

2 The term 'digital Darwinism' was coined by KREUTZER and LAND and describes a situation in which technology and society change faster than companies are able to adapt. [8]

3 A strictly methodical application e.g. of the scenario technique, in the sense of a scientific elaboration, has been dispensed with.

2

PARADIGM CHANGE THROUGH THE DIGITALIZATION OF MOBILITY AND LOGISTICS

2.1 The third wave of digitalization and Business 4.0

The phenomenon of digitalization is neither new nor altogether unfamiliar to its principal actors such as producers/consumers, enterprises/households, economy/science. We are already riding, in fact, the third wave of the digitalization that ensued from the advent or widespread use of computers in the late 1980s. The first wave began with the commercialization of the Internet: the so-called 'dotcom era' that saw for the first time information disseminated digitally over a wide geographical area to the masses. This wrought massive changes in the way goods and services were produced and purchased. [9]

The second wave of digitalization was heralded by the development of 'Web 2.0'. Harnessing the talent and expertise of a multitude of individuals resulted inter alia in the development of a better and cheaper manner of providing services and information than major enterprises at the time were in a position to provide: the birth of Wikipedia et al. [9]

With the current wave of digitalization, the third stage has been reached; and it can safely be assumed that once again we will see the manner in which goods are manufactured and distributed undergo a radical transformation. It's true that each of the previous waves of digitalization had drastic implications for day to day business, but the most profound changes to date for a multitude of industries and organizations have been attributed to the current wave [9] – the disruptive transformation of whole economies and societies.

Manufacturers in particular see in this an opportunity to increase their international competitiveness and secure a decisive competitive advantage. Just when they seemed to be running out of instruments for improving efficiency, a new lever, and with it, the possibility of attaining a new level of efficiency, appeared in the shape of digitalization.

'Industrie 4.0'[4] was the name given by the German government to a draft research agenda to promote the competitiveness of German industry in the digital age. Since then, the suffix '4.0' has found its way into discussions of many areas of daily life as a shorthand for the changes wrought by the new technologies and the current wave of digitalization.

However, to see digitalization purely as a tool for promoting efficiency is a fatal error; that is merely one of multiple perspectives from which the phenomenon is, and ought to be, viewed. In Germany, as initiatives such as 'Industrie 4.0' clearly demonstrate, digitalization is increasingly viewed as a means of optimising resource management and capacity planning (i.e. B2B-focused); elsewhere though, and particularly in Silicon Valley, the current wave of digitalization has far more to do with improving the management of customer relations (B2C focused). Already during the 'dotcom era' and Web 2.0 it was evident that, with the advent of new technologies, enterprises would have to refashion their business models and value creation chains to have any hope of remaining relevant to the market and, above all, to their customers. If you look at the changes associated with the current wave of digitalization, you soon realize that the central protagonists of the current digital transformation are the efficient use of large quantities of data and the interconnection of elements from the digital and the real world. In other words, enterprises have to become data-driven and digital: part of the 'Internet of Things'. This also influences the manner in which we move ourselves as individuals using private or public transport as well as how we monitor and orchestrate the movement of goods.

According to some estimates, by the year 2020 there will be around 50 billion networked 'things' in existence [11] simultaneously generating and sharing a multiplicity of data. The challenge for enterprises is to make effective use of this data to improve processes, products and decisions or generate new sources of income – and, ultimately, better understand their customers. All data useful to such analyses therefore need to be available to all units within each organization from a central point – a rationalization very few enterprises have thus far managed to

[4] The suffix '4.0' is based on the assumption that today's digitization will inaugurate the Fourth Industrial Revolution (as mechanization, mass production and automation spawned its predecessors).

realize. The potential of data-driven decision making was demonstrated by empirical research conducted by *BRYNJOLFSSON* and *McELHERAN*, who found an increase in productivity of around three per cent. [12]

Notwithstanding such research, very few enterprises seem disposed at the present time to exploit this potential. Indeed a study from *EY* established that, whilst 81% of the senior decision makers asked expressed themselves convinced that decisions in the future would have to be data-driven or -supported, barely 31% had even begun restructuring their operative processes to allow such a transformation.

The successful implementation of such a transformation presupposes, moreover, a paradigm change in the handling of data. Where previously processes centred on decision support systems and programs, the focal point in future must be the data itself. A paradigm change from application-centricity to data-centricity has to occur. In this respect, data are not merely the new oil but also the new purple of digital society: if data, like the colour purple in the Middle Ages, has so far been reserved for a privileged elite of employees within each enterprise, now it has to be thrown open to the entire workforce, so that decisions can be taken decentrally and new turnover potential realized. [14]

The current wave of digitalization is also expected to bring increased 'service orientation'. The term 'servitization' was coined in the late 1980s to describe an emerging trend in corporate strategies towards offering 'product + service' packages rather than products alone.

So enterprises will concentrate increasingly upon offering results rather than the equipment required to achieve them. Whilst this has long proved a successful business model for companies like the aero engine manufacturer Rolls-Royce,[5] the current wave of digitalization affords numerous opportunities to apply the same principle in many other industries. The *WORLD ECONOMIC FORUM* sees the attainment of a servitized economy as a four-step process (shown in Fig. 1), the nirvana of which is the 'outcome economy', in which value is a pure function of measurable results.

The field of mobility in particular conceals enormous servitization potential. It is conceivable, for example, that the automobile concerns of tomorrow will be offering their customers certain levels of mobility or hours of vehicle availability rather than vehicles of their own. But on the way to the outcome economy – step two of the process, perhaps – one can envisage auto manufacturers guaranteeing the customer's mobility in his or her own car by bundling the right to free maintenance and repairs with the vehicle sold.

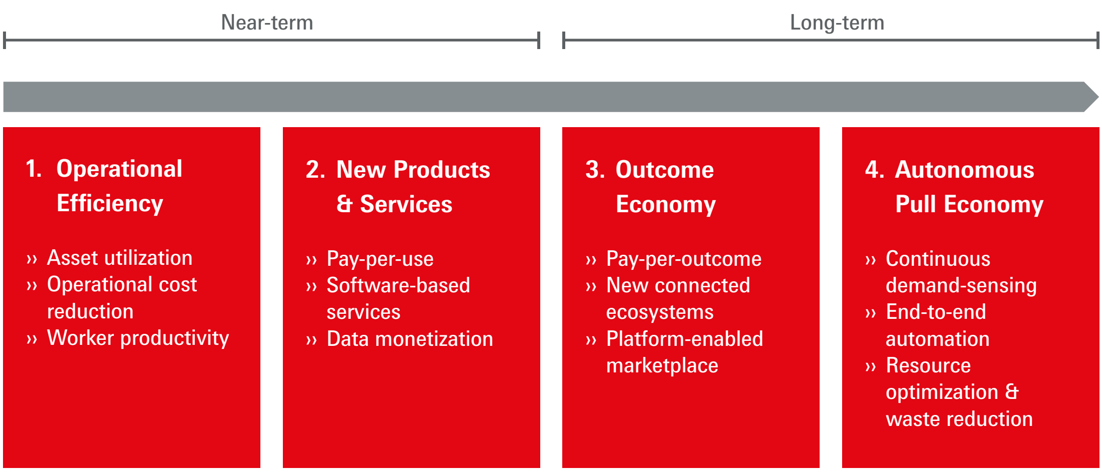


Fig. 1: The way to the 'outcome economy'; source [16]

[5] The Rolls Royce 'Power by the Hour' concept (applied to its aircraft engine business) involves the billing of operating hours (and fractions thereof), which then serve as the basis for the sum finally invoiced. The engine itself is never sold to the user.

2.2 From B2C to B2Me – customer-centricity as the highest maxim

2.2.1 The needs of the 'digital consumer'

In the long term, the needs of consumers are only conditionally constant and their expectations in terms of products and services endlessly redefined. No sooner have most of the consumers' demands been satisfied than they start to want newer, better and/or more expensive products that each individual fondly supposes will set them apart from the herd. [17] The ability to recognize such changing expectations and demands is essential to the long-term success of an enterprise. [17] Just as the substitution in the late 1960s of buyer-oriented for seller-oriented markets gave consumers more say, and greater sway, in the market, the new technologies and the increasing market transparency that comes with them are adding further scope and consequence to their decisions. At the same time, these technologies are influencing and changing the behaviour of consumers.

There have been numerous studies investigating the extent to which consumer behaviour is changing in the digital age. Whilst there may be no detailed consensus, the broad findings of these studies concur and yield a four-dimensional image of consumer behaviour in the digital age. The four axes are:

›› Customization
›› Commoditization
›› Convenience
›› Collaboration

Customization or individualization is primarily driven by the pluralization of lifestyles. As many studies (e.g. [18, 19]) have found, individuals are diverging ever more widely from classic living patterns, generating a demand for products in keeping with the lifestyles to which they variously aspire. The younger generations[6] primarily attach more worth to the personalization of products and services – a tendency to which the current wave of digitalization can only add momentum. According to a representative study with 1,560 participants conducted by the management consultancy *DELOITTE*, around 36% of the population of the UK are interested in personalization options for products, with 20% prepared even to share information with enterprises in order to obtain more personalized products. This study found the type of product to be determinative of the level of demand but no significant difference between generations. Studies for the German market yielded similar results (e.g. [18, 19]).

The demand for a greater variety of products is plotted along the commoditization axis. With ever more products on the market, and increasingly little difference between them, markets become homogeneous, with price the sole criterion for preferring one product over another. This reflects a paradox of the digital age: whilst products and services are becoming more personalized, the advancing wave of digitalization seems to be effacing differences between the suppliers themselves and between their respective competences. Due to the circumstances described above, consumer behaviour in 'commodified' markets is usually much more opportunistic than in non-commodified markets. It can be assumed that digitalization will only reinforce this tendency; already the efficacy of traditional methods of securing customer loyalty is seen to be waning. [21] The management consultancy *ACCENTURE* views the erosion of customer loyalty as a result of digitalization as one of the most important findings of a study it conducted with 23,600 participants from over 33 countries. [22] According to the report: not only do consumers now look for more options – and more companies to serve them – but are also far more ready to compare what their current suppliers are offering with what is available elsewhere. The same study revealed that participation in customer loyalty programmes is also increasingly short-term and markedly more opportunistic, driven primarily by the desire to gain access to the 'best deals'.

[6] By 'younger generations' the authors mean those born in the early 1980s or later. Such people are also referred to as 'digital natives' because they grew up with fundamentally new technologies such as the Internet.

The availability of new technologies has also led customers to set much store by convenience. They are less and less inclined to invest much time or effort in purchasing decisions. [22] We see the 'paradox of choice' at work here: with so many alternatives on the market, customers can seldom be certain of having made the right decisions, and this engenders dissatisfaction. [23] As with the customization of goods, digital consumers wish to be offered services that correspond exactly to their tastes and requirements – but with as little expenditure of effort on their part as possible.

Greater importance is often attached to use (rather than exclusive access to or possession) of the service or product in question (Collaboration). The so-called 'sharing economy'[7] has seen considerable growth in recent years. In 2013, the global market volume of the 'sharing economy' was already estimated at 26 billion US dollars, and this will more than quadruple (to around 110 billion) in the years ahead. [25] Growth rates of approximately 25%, in some sectors of the economy of up to 65%, are expected between now and 2025. [26] On a wide variety of platforms and in ever greater numbers, people are offering to share their own spare capacity (e.g. living or car space) with others, for a small consideration to offset expenses. Such platforms allow users to communicate swiftly with one another and collect whatever information they require. They are gaining increasing acceptance in the job market as well, primarily because they allow enterprises to make flexible use of, and supplement, the talent and expertise at their disposal.

Interestingly, the changes in consumer behaviour described in the preceding paragraphs are not confined to end customers. Industrial customers are increasingly assuming the characteristics of end consumers and making demands similar to theirs in terms of service and personalization. The phenomenon of 'industrial consumerism', according to estimates by *ACCENTURE*, will influence the market for business-to-business (B2B) products and services to a massive extent by 2020. Like end consumers, B2B customers are considerably better informed these days and expect a significantly more immersive experience when dealing with traditional sales and marketing organizations. [27] Some 80% of the companies asked expressed the conviction that B2B customers are becoming more self-directed and put a high value on industry-relevant and tailored expertise [27], reflecting clearly the desire for customization.

2.2.2 What users expect from the mobility and logistics of tomorrow

It is highly likely that digital consumers will make the same demands of mobility services. However, the specific position of mobility in everyday life must be taken into account here, as this, too, will influence expectations placed on the mobility services and service providers of the future. Compared to other consumer needs, mobility is regarded as of secondary importance – as a means to an end rather than satisfying some primary need. [28] Services in logistics are viewed in exactly the same way. Therefore, one of the major challenges of future logistics and mobility services is to be better integrated into other everyday activities of the consumer. In urban areas in particular, it is noticeable that consumers with increasing frequency opt for multimodal solutions; they are no longer willing to limit themselves to just one or a few selected means of transport for certain routes. [3] The services providers of tomorrow must therefore offer their users maximum flexibility in the choice of means of transport and delivery options, without making them dependent on ownership of a means of transport (Collaboration; 'Mobility as a Service').

On the customization axis, mobility and logistics services will have to take several factors into account before they can arrive at the best possible offer for digital consumers. In addition to personal preferences in terms of price, time and comfort, any aversion to certain means of transport, or their use at certain times of day, must also be taken into account. In addition, digital consumers want services that accord with their chosen lifestyles.

[7] As defined by Teubner et al., the term 'sharing economy' covers all business models, platforms, communities, etc. that make it easier for individuals to share wholly or partially unused resources with others. [24]

Although a study by *DEUTSCHE POST DHL* may have dismissed the so-called 'lifestyle of health and sustainability' (LOHAS) as a niche trend, there is no denying that a clear demand exists for more environmentally conscious logistics services. [29] Since the personalization of services requires a significant amount of data, service providers are to a certain extent reliant on the willingness of their customers to provide it. In Germany, in particular, considerable importance is attached to the protection of (personal) data from dissemination and unwanted analysis/evaluation, with older people particularly fearful of misuse.

Where commoditization reigns, it can be assumed that digital consumers – especially in the logistics and mobility sectors – will (continue to) show little loyalty towards service providers. It is important to differentiate between companies that offer pure transport capacities and those that provide personalized solutions for their customers. Even though both types of service provider will be affected by commodification, standard services (such as those of the classic TTS market[8] and the operation of pure local public transport services) will be even more commodified in the digital age. Through improved interface integration and standards, however, logistics service providers will also be affected by the increasing convergence of core competences brought about by digitalization. Much the same applies to mobility companies, whose unique selling points are likely to become increasingly blurred.

Even the previously unscathed car industry is now displaying early symptoms of commodification that the transformation of the car into a 'mobility device' will do little to relieve. Thus, the identity of the service provider is increasingly of secondary importance; what counts is the quality of the service, which must be dictated by or adapted to the requirements of the user. [30]

The provision of a service is influenced by the convenience factor in several areas. To start with, the search for, booking, and payment for, a service must be simple and capable of being conducted in a uniform way e.g. using a single app. It is also important that any changes from one means of transport to another are smoothly coordinated – indeed seamless. The proverbial first and final miles[9] are currently the trickiest stretches to be negotiated if local public transport is to compete on equal terms with other means of transport. [31] With the aim of dovetailing better with the everyday activities of users, the provision of entertainment and location-based services during journeys might be worth examining. In a study by *MESSE FRANKFURT* and the logistics institute *SCM@ISM* at the International School of Management in Frankfurt am Main, 47% of the 486 participants asked reacted positively to the idea of functions such as the recommendation of music or films of a length adapted to the journey. [30] Forty-six per cent also said they would be very interested in being informed of sights and other places of interest along the way or near the destination. As regards convenience, customers will be every bit as demanding in their dealings with logistics service providers, expecting them to deliver ever smaller packages, often containing personalized components, ever more swiftly.

2.3 Decarbonization and the sustainability of mobility and logistics

The first attempts to develop a concept of sustainability can be traced back to 18th century German forestry legislation. Published in 1713, *'Sylvicultura Oeconomica'* by Hans Carl von Carlowitz describes a concept based on the principle that only as many trees should be felled as could grow back again to maintain the stock at the same level in perpetuity. [32, 33] But despite longstanding acknowledgement of the principle, the term sustainability is differently understood and no clear definition has yet won acceptance, which is why in practice there are wide

[8] The 'TTS market' combines the classic logistical activities of transport, transshipment and storage.

[9] When discussing local public transport networks, the 'first' and 'final' miles are those stretches of the journey (whatever their actual length) that extend, respectively, from the user's starting point to the nearest point of access to public transport (e.g. a bus stop), and from the last such point of access used to their actual destination.

divergences in its use. From the quest to model a holistic concept of sustainability, however, three core thematics or dimensions have gradually crystallized, and it is these that are most frequently invoked when the term 'sustainability' is used today.

- ›› Economy – e.g. the efficient use of (finite) resources and proof that more value has been generated than destroyed
- ›› Ecology – e.g. the preservation of biodiversity as well as the reduction of harmful emissions and waste
- ›› Social responsibility – e.g. the creation of humane and secure jobs, the maintenance of social harmony, and compliance with ILO guidelines[10] on child labour and minimum standards

On this analysis, the interests of sustainability are only served when equal consideration is given to all three dimensions. *ELKINGTON*, for example, illustrates this with a Venn diagram, finding sustainability uniquely within the area where the three circles (Social, Environmental, Economic) overlap. [35]

The model for a holistic approach to sustainability best known in the German-speaking world is the three-pillar model (derived from the sustainability triangle proposed by the federal government of Germany) according to which, rather than as circles or dimensions, the three values are portrayed as parallel pillars upon which the pediment of Sustainability rests. [34] However it is precisely this parallelism of the three pillars of sustainability that often leads in practice to the three values being played off against each other, allowing success to be claimed without much expenditure. [33] The reduction of greenhouse gas emissions through fuel economies is a frequent example for mobility and logistics enterprises. Furthermore, the profits are often privatized in consequence whilst at the same time the costs of environmental pollution are socialized. To take on board such objections, *STAHLMANN* offers a weighted version of the pillar model showing the conservation of natural resources or the fight against climate change – i.e. preservation of the ecological balance – as the foundation of sustainable development. Fig. 2 juxtaposes four models of holistic sustainability.

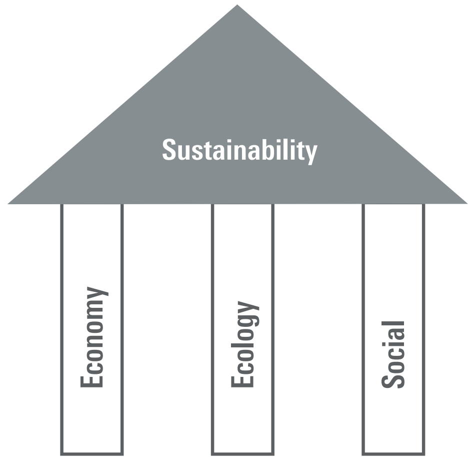
From the standpoint of future traffic systems and in view of the criticisms outlined in the previous paragraphs, the weighted pillar model would seem the most pertinent reference model for the sustainable development of our transport systems. Since the transport sector is responsible for a large proportion of the total annual greenhouse gas emissions and air pollution, and therefore the destabilization of the ecological balance, it is of crucial importance to stem this flow if the sustainable development of traffic, mobility and logistics is to be achieved. Decarbonization, air pollution control and stabilization of the ecological balance must therefore be assured; without this, the four pillars of sustainability have no secure foundation upon which to rest.

2.3.1 The challenge of decarbonizing transport

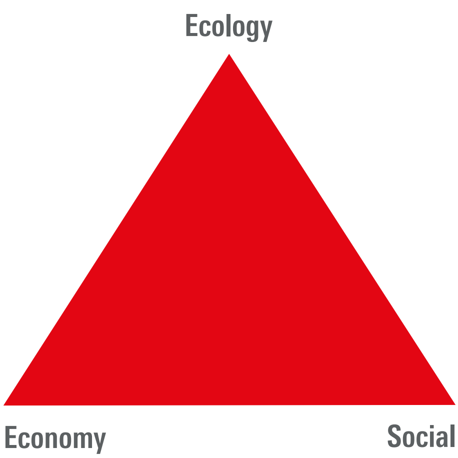
Environmental protection and maintenance of the ecological balance have long been key objectives of legislation in the Federal Republic of Germany. Article 20a of the German Basic Law, for example, entrenches protection of the environment and the quest for sustainable development. Furthermore, Germany is committed as a result of its participation in international climate protection initiatives and conventions to achieving a quantifiable reduction in climate-changing greenhouse gases such as carbon dioxide (CO_2). The Kyoto Protocol signed in 1997, which came into force in 2005, commits all participating industrialized countries, as part of a two-phase approach, to a binding and quantifiable reduction in emissions dependent upon their level of economic development. For the first 'commitment phase' between 2008 and 2012, Germany undertook to reduce greenhouse gas emissions by 20% compared with the reference year 1990, which it did with room to spare. [36] For the second period, running from 2013 to 2020, a further reduction of 20% is stipulated, however doubts are being expressed openly in the federal

[10] The ILO Guidelines are a standard issued by the International Labour Organization (ILO) to promote humane and safe working conditions (e.g. through the outlawing of forced labour or discrimination).

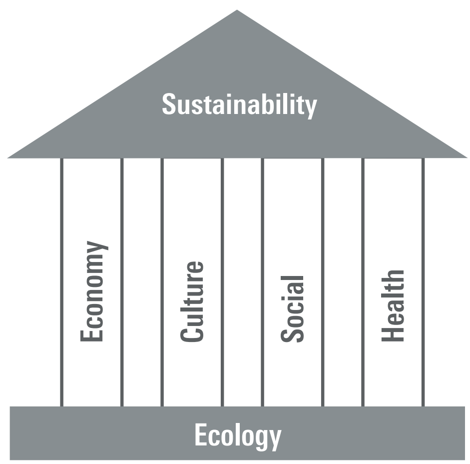
ELKINGTON's 'Triple Bottom Line' approach



The Three Pillar model



The Federal government's
'Sustainability Triangle'



STAHLMANN's 'Weighted Pillar' model

Fig. 2. Sustainability models compared

government as to whether this is feasible. These aspirations were reaffirmed with the entry into force of the Paris agreement, which was adopted at the 21st UNFCCC[11] Climate Conference in December 2015. This is an international climate treaty binding between all contracting states for emissions reduction and has already been adopted by 196 member states of the UNFCCC; by April 2016, 195 nations had signed. [37] The objective of the agreement is to put a ceiling of 2 per cent on global warming compared to pre industrial levels, with a reduction to 1.5 per cent sought by all participants. [37] It was further agreed to maintain greenhouse gas neutrality between 2050 and 2100, which would require eliminating altogether the use of fossil fuels. In order to guarantee the attainment of these goals, the industrial countries without exception committed themselves to assist developing countries individually to achieve their respective climate goals. [37]

Despite all the aforementioned efforts and the operationalization of emissions reduction measures by the respective countries, it seems unlikely at the present time that this will be enough to limit global warming to 2°C. According to recent analyses and projections, the current voluntary commitments of the individual countries are barely sufficient to limit the rise to 3° C above the pre-industrial level. [38] Observation of the real emission development would suggest, if the status quo were maintained, a rise of 4° or more. [38] The consequences of global warming are inter alia an increased risk of extreme weather events threatening economic, ecological and social capital at the same time. Germany is already one of the countries hardest hit by such weather extremes. In fact, the Federal Republic ranks twentieth among the countries most often afflicted by extreme weather events between 1994 and 2014. [37] According to scientific forecasts, the annual cost to Germany alone of climate change could be anywhere between 8 and 21 billion euros by 2050. [39] An intensification of climate protection measures is therefore not only desirable but also highly likely to occur.

The transport sector, in particular, has so far made scant contribution to the attainment of climate goals. Between 1990 and 2012, greenhouse gas emissions were reduced by a mere 5.2%. In fact, when international air and sea transport are factored in, they actually rose by 2.5%. [40] The 15 largest ships in the world alone emit each year the same quantity of pollutants as 750 million cars. Furthermore, few forecasts expect there to be any reduction in the future volume of road traffic. [41] Since this accounts for around 20% of all climate-relevant greenhouse gas emissions [41], there have to be significant changes – especially with regard to emissions attributable to private vehicle use. According to the *GERMAN ENVIRONMENT AGENCY*, around 24% of all such emissions are attributed to the private consumption of mobility activities, and around 75% of these to private motorized transport. [42] It is therefore hardy surprising that the transport sector is one of the main starting points for achieving Germany's defined climate change targets. In addition to the imposition of stricter limits on the emission of CO_2 by cars and tightening restriction on air pollution in the inner cities, by 2020 10% of the energy needs of the transport sector must be met by renewable energies. [41] And in the wake of the diesel scandal, complaints relating to compliance with NO_2 limits and master plans to achieve sustainable urban mobility have become the concern of the courts as well as the cities affected by the exceeding of limits. The Federal government's programme of short-term measures 'Clean Air' is intended to accelerate the pace of change in the transport and mobility sectors between now and 2020. Otherwise, diesels risk being banned altogether from German city centres.

To further these and other climate and environmental objectives in the transport sector, the various regulatory instruments listed in Fig. 3 are likely to be employed.

As Fig. 3 shows, the relevant regulatory instruments can be divided into four groups according to their intermediate objective: i) reducing the volume of traffic; ii) favouring other modes of transport; iii) increasing energy- or vehicle efficiency; iv) use of more environmentally friendly propulsion technologies or fuels. On this basis, potential measures to reduce the contribution of the transport sector or the logistics and mobility market to the destabiliza-

[11] The United Nations Framework Convention on Climate Change (UNFCCC) is an international climate agreement aimed at limiting disturbance to the climate system caused by human activity. The agreement is currently ratified by some 195 states.

tion of the ecological balance can be elaborated. It should be noted that certain of these measures could be seen as serving several intermediate objectives and address both private and business actors in the transport sector.

As price is one of the most effective levers for controlling user behaviour, it can be assumed that many of the measures described above are aimed at placing an additional burden on the personal mobility budget or at increasing the costs of providing transport services. For example, congestion charges (i.e. charges for the use of inner city infrastructure dependent upon traffic density) might be introduced. A similar tax was first levied in the British capital, London, in 2003 and since its introduction is said to have reduced the volume of traffic by around 20%. [43] The level of occupancy of the vehicle could also be factored in when calculating congestion charges, which could incentivize modal shift as well as reducing traffic volume, and could therefore be seen as an opportunity for alternatives such as public transport or cycling. Nor should an increase in the tax on fossil fuels or the extension to motor vehicles of emissions trading (used already in aviation) be ruled out.

One could cite also instances from other European countries in which the inner city infrastructure – in particular, the number of available parking spaces or traffic lanes – has deliberately been reduced to encourage people to use other modes of transport. In Paris, for example, the three kilometre long stretch of road between the Place de la Concorde and the town hall, which was closed for four weeks as an experiment in the summer of 2017, will

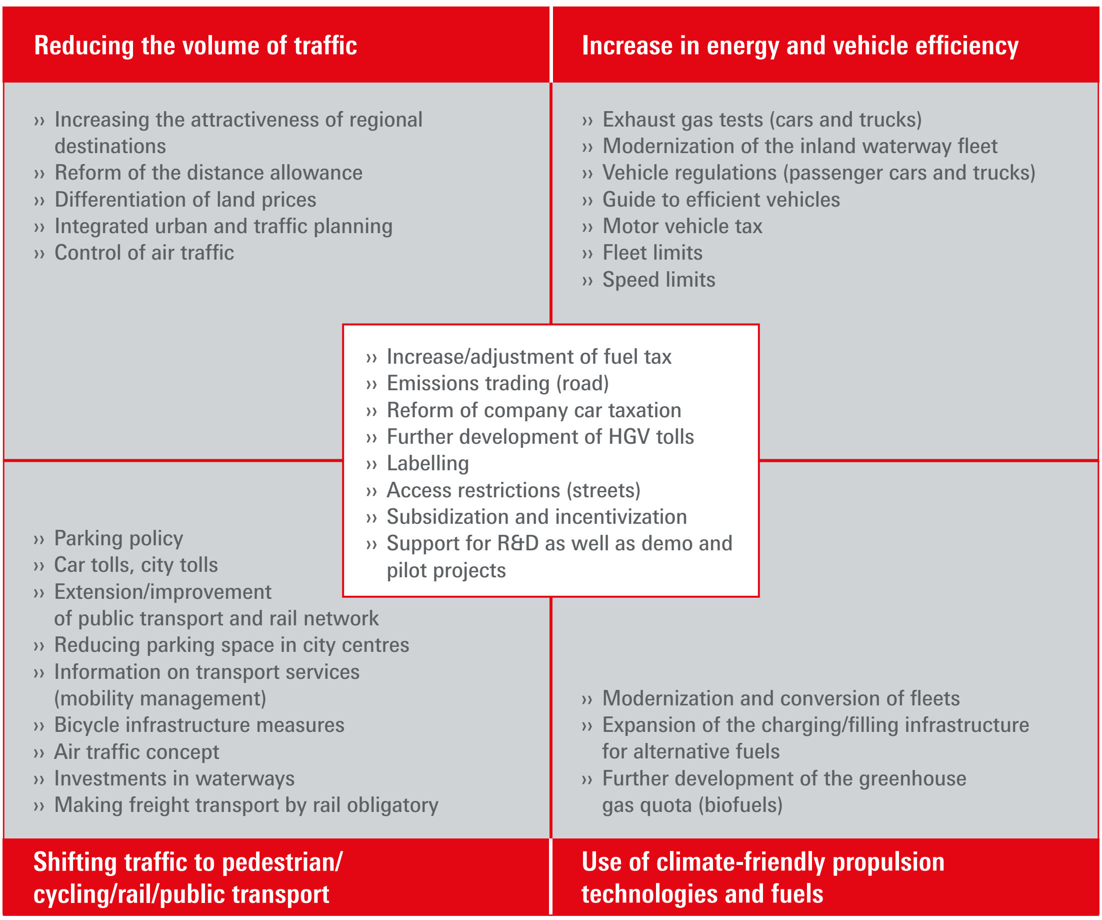


Fig. 3: Regulatory instruments for achieving climate targets; source: [41]

soon be closed all year round. [44] The throughput of traffic on the stretch in question is currently 43,000 vehicles per day.

With a view, in particular, to improving the quality of the air in the inner cities, it is conceivable that further proliferation of the environmental zones already seen in many German cities will occur. This increases mobility costs indirectly through the gradual tightening of limits and forcing companies to modernise their vehicle fleets. The same goes for general interdictions on certain types of vehicle. By 2025, for example, diesel powered vehicles are set to be banned altogether from the centres of Madrid, Paris and Athens, [45] The city council of the Norwegian capital, Oslo, is even pondering a complete ban from the city centre of all vehicles that are not 100% innocent of pollutant emission. By the same token, Hamburg is the first German city to have introduced a partial ban on diesel vehicles as well as implementing the first closures of strategic stretches of road. It is doubtless only a matter of time before other cities follow Hamburg's example, as the measured pollution levels in German cities often exceed for long periods the limits imposed by the European Union (EU). According to the *FEDERAL DEPARTMENT OF THE ENVIRONMENT*, in 2016, 57% of the registered measuring stations recorded nitrogen dioxide (NO_2) levels in excess of the specified limit. [47] The need for local authorities to take action is therefore indisputable. Further pressure to act is coming from non-governmental organizations (NGOs) such as German Environmental Aid (DUH), which brought actions against several federal states responsible for the planning of air pollution control in eleven major German cities for violation of, or non-compliance with, the norms [48] and, encouraged by the Federal Administrative Court ruling of February 2018, looks set to bring further complaints.

What emerges most clearly from the preceding paragraphs is that the decarbonization of transport is making inexorable progress – and at no mean pace. Whilst already today such developments could be considered challenging. a look into the near future further dramatizes the current situation. According to estimates by the *UNITED NATIONS (UN)*, around 54% of the world's population, and 75% of the inhabitants of Germany, live in urban areas. [49] These figures are expected to rise to 66% and 83% respectively by 2030. [49] Combine this with rising population growth, and a significant additional burden on urban infrastructures can be expected. This means not only many more traffic jams but also the exacerbation of traffic-related nuisances like noise pollution, an increased risk of accidents and still higher levels of climate relevant greenhouse gases. The fact that CO_2 emissions increase dramatically at speeds of 20 km/h and below [50] will do nothing to facilitate the decarbonization of traffic. And the diesel-powered delivery vehicles of the logistics service providers, which frequently hold up traffic in city centres, undeniably bear much of the responsibility. This is one of the reasons why the cities threatened with diesel bans are looking hard now at urban logistics and will seek to influence further development through judicious regulation.

2.3.2 The neglected dimension: 'social responsibility'

In comparison to the other dimensions of sustainability, Economy and Ecology, the social dimension often receives little attention. It is nonetheless of great importance for the design of future transport systems and the future of mobility. The changes we are seeing now of socio-cultural origin have significant implications for the future design of sustainable transport systems. Two trends are particularly noteworthy: the increasing age of the population and globalization or migration.

According to *UN* forecasts, the median age of the world population will be around 33.1 years in 2030; in Germany, however, by this time it is projected to have risen to 48.6. [51] This means that in some 13 years, half the German population will be more than 50% older than a large part of the population of the world. This trend is having a considerable impact on the design of future transport systems and the logistics and mobility services they will offer. On the 'universal design' principle, wheelchair access to railway stations must be guaranteed and booking and payment methods simple and easily understood by all. Furthermore demographic changes place demands upon the service itself. In 2014, for example, around 32% of the over 65s in the EU lived alone. [52]

Sustaining the personal mobility level of this population group as it ages will presumably require quite different needs to be met. Mobility service providers and infrastructure enterprises will have to anticipate and make provision for these, too, if they are to satisfy their statutory obligation to promote – or, at any rate, do nothing to inhibit – social inclusion. Logistics service providers could even expand their portfolios to include assuring the supply of household provisions to this group through things like shopping services. At the same time, however, a large number of studies, particularly in the west, are predicting a marked rise in poverty among the elderly. A representative study by the *DIW* and *ZEW* covering more than 12,000 households takes it as given that by 2036 around 20% of over 65-year-olds will be stricken by poverty. For this reason, care must be taken to design mobility systems that will be affordable. Progressive globalization and other geopolitical events, such as wars, mean that the destinies of world populations are ever more tightly intermeshed, one consequence of which is to present mobility service providers with a customer base increasingly diverse in terms of geographic origin. Overcoming language barriers therefore represents a further challenge facing those designing and providing services to facilitate the negotiation by newcomers and visitors to the country of unfamiliar transport systems.

It is more than likely that increasing recourse will be had to the so-called ‘universal design’ principle in the quest to satisfy the more stringent requirements of the socially sustainable traffic and mobility systems of tomorrow. An object or service is said to respect the universal design principle when any potential user, regardless of their intellectual or physical limitations, is able to use it unassisted. Such limitations include not only physical disabilities but also things like language difficulties or unfamiliarity with the location. The study by *MESSE FRANKFURT* and *SCM@ISM* to which we have already referred also investigated attitudes to such an approach applied specifically to the design of mobility services and some 70% of the consumers interviewed stated that they were in favour. [30]

2.4 Disruption as the new ‘business as usual’

2.4.1 How technology is driving innovation and development

Successful managerial leadership has always been associated with the ability to adapt to drastic changes – ‘disruptions’ – usually occasioned by external developments. 52% of the companies that made up the Fortune 500 in the year 2000, for example, have since either become insolvent, been taken over by competitors, or ceased altogether to exist. [54] The average tenure of companies in the Standard & Poor’s 500 index has also shortened drastically, from 61 years in 1958, to 25 years in 1980, to a mere 18 years in 2001. Nonetheless, it is to be observed that companies are being called upon ever more frequently to adapt, and to do so ever more swiftly. With increasing digitalization as the catalyst, companies are increasingly being faced with the challenge of reinventing themselves and the products or services they offer. The current wave of digital disruption, however, differs in two important respects from the conventional – the *traditional* – dynamics of the market: firstly, in that the pace of the change is markedly accelerating; and, secondly, because we are seeing the erosion of an ever greater share of the competitive advantage of the market participants affected. [55] According to an industry transcending survey by *OXFORD ECONOMICS* and *HP*, companies feel that the already significantly increased pressure to innovate is still on the rise. 49% of the 300 decision makers asked said they intended to reduce their ‘time to value’ (their product development and introduction cycles) significantly by 2018, in order to remain relevant in their respective markets. Interesting, the executives interviewed were more concerned at the threat of being squeezed out by established competitors than by start-ups new to the market.

There can be no doubt that technological progress is contributing significantly to this development. Even if innovation is by definition unforeseeable or unexpected [57], the introduction of new products and services is closely linked to the development and (increased) availability of new technologies. This is because innovation in many cases constitutes the commercial exploitation of new technologies or the packaging of some new technolo-

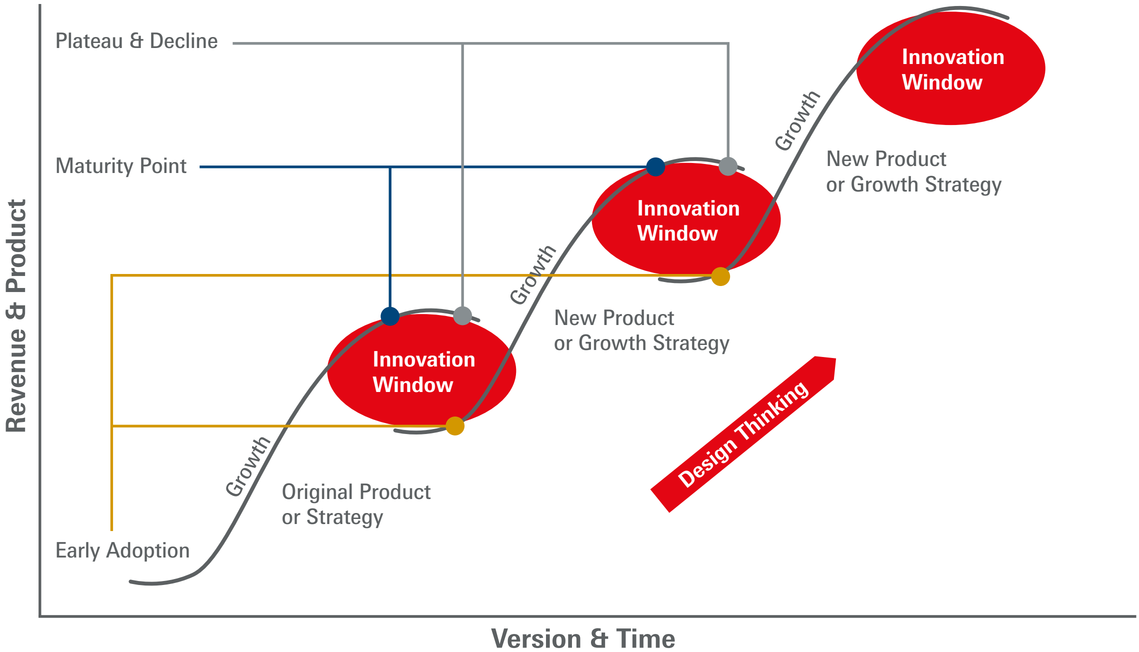


Fig. 4: Foster's S-curve model

gy into a profitable business model. The life cycle of innovations – whether technical or entrepreneurial – is therefore best represented by *FOSTER's* S-curve model. The model is based on the technology lifestyles model developed by Arthur D. Little and describes how technologies that are initially in some respects inferior, prevail in the long term as the performance limits of established technologies are reached. The model therefore represents an attempt to describe the inception and evolution of radical or disruptive innovations. [59]

As can be seen from Fig. 4, at the beginning of their life cycles, the performance of (technological) innovations is underwhelming, and further development efforts are called for. Furthermore, the acceptance and adoption rate in the early stages is relatively sluggish. After a phase of continuous growth, in terms both of performance and of the rate of adoption, they later attain maximum maturity, before their performance stagnates and eventually falls away. The decline in performance goes hand in hand with the development and introduction of new technologies, which – in the archetypical representation – occurs shortly before the attainment by the established technology of peak maturity. Ideally, companies are aware of the state of maturity of the technologies they are employing and switch at the right moment to newer technologies capable of outperforming them.

The same logic can be applied to changes in core competences or services. There are numerous examples of companies changing – some successfully, some less successfully – their core businesses or switching at the right moment to a new S-curve. The online streaming service Netflix, for instance, which began life as a DVD rental company, recognized the limits of the technology upon which its business at the time was based and transformed itself, at the opportune moment, into a provider of video-on-demand, expanding this core business in turn to include the production of its own series. For many manufacturers of satellite navigation devices, it was a very different story. Within a short time of the introduction of smartphones, these lost up to 85% of their market capitalization, from which very few manufacturers recovered. [60] The erstwhile film manufacturer Kodak also failed to recognize the limitations vis-à-vis digital photography of the technology upon which its business was based and went bankrupt in 2012 – and that, despite the fact that the company is credited with the *invention* of the digital

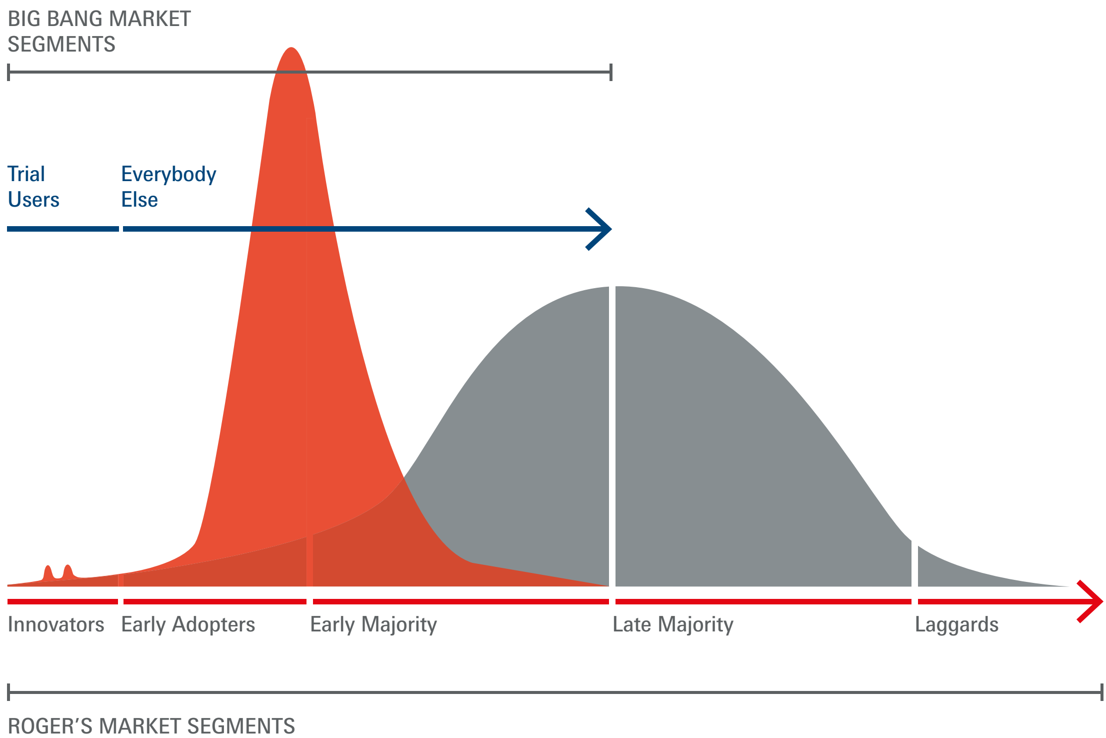


Fig. 5: Comparing the market adoption rates of big bang disrupters and 'normal' products; Source [60]

camera! Although Moore's Law[12] of 1956 may have been pronounced dead [61], we can still assume that the innovation curves in Fig. 4 will become steadily steeper, further fuelling the constant acceleration identified earlier as the prevailing trend. With the shortening of life cycles comes the increasing risk of exceptional events known as 'big bang disruptions'. Big-bang disrupters skip a large part of the product development cycle typical of conventional innovations, their adoption being often immediate and universal. This happens because big bang disrupters – even at the time of their market launch – are not only cheaper but also already superior in quality to comparable alternatives. [60] To illustrate this effect, Fig. 5 shows the market adoption rate (not the product life cycle) of such a disrupter.

Big bang disrupters do not even see the companies displaced by their products necessarily as direct competitors. When the advent of some novel approach to satisfying their customers' needs occasions the demise of established products, this is often more akin to collateral damage, the disrupters' objective having been the conquest of a quite different market. Considering that in many industries not only new technologies but also radical innovations are being introduced almost exclusively by companies not previously active in the markets they overrun [62], incumbents are in double jeopardy: their products must not only prevail against those of their traditional competitors but also withstand the onslaught of new, sometimes radical, innovations.

[12] Moore's Law states that the number of transistors that can be fitted onto an integrated circuit of unchanging size doubles approximately every 12 to 24 months, which is often equated with a doubling of the computing power of processors. However, the period of doubling varies according to source.

2.4.2 The implications of digital disruption for mobility and logistics

Compared to other industries, mobility service providers[13] – with the exception of automobile manufacturers and airlines – seem to have been largely spared radical disruptions to date. Companies offering their services in the urban transport sector in particular have remained almost entirely unscathed by radical technological upheavals despite the enormous technological changes. However, this seems to be changing with the current wave of digitalization. It seems that this technology, possibly in combination with other new technologies, has the potential to be packaged into a profitable business model for logistics and mobility services, putting significant pressure on traditional business models. Due in particular to the constantly increasing availability of data of all kinds, the market for logistics and mobility services is attracting many new companies that could radically alter it.

It can be assumed that companies will have to transform themselves into integrated mobility providers offering far more than just online or mobile ticketing and a route-planning app if they are to respond adequately to the changes in consumer behaviour described in Chapter 2.2. Mobility offers must be multimodal and adapted to the individual preferences of each customer. The much vaunted 'customer experience', i.e. the sense of having benefited from a service, will become increasingly relevant and offer a decisive competitive advantage here, as is the case already in many other industries. The use or booking of services must therefore be simple and uncomplicated, and information must be available at all times and everywhere – in real time. Furthermore, mobility and transport must be linked with, or integrated into, their users' other needs. It is precisely here that the potential for radical disruption is significantly high.

Currently in the literature (e.g.[63-65]), two archetypes of such comprehensive business models (and their hybrid forms) are being discussed, which at the same time illustrate the paradigm shift that mobility service providers (and in some cases also logistics service providers) are undergoing at the present time. On the one hand, the asset-driven 'integrative approach' is discussed, which basically describes the behaviour of current mobility providers. Mobility services are offered by one or several enterprises, making use of assets they have already acquired. The expansion of the range of services is almost exclusively realized through the vertical integration of further companies, with a view to making possible an, ideally unbroken, perfectly coordinated, and seamless, multimodal mobility chain, offering a uniform degree and quality of service. Given the axiomatic need for physical assets, it is not surprising that this approach is ascribed above all to companies that already possess substantial assets for the provision of mobility services.

This asset-driven approach is contrasted with the data-driven, 'aggregating approach'. This is based on making use of the existing services of various providers, but combining and presenting them to consumers through the medium of a user-friendly interface, thus increasing their utility in day-to-day use. Planning, booking and payment are also handled by the aggregator or curator. Comparing theirs with the integrative approach, we see that mobility curators require significantly fewer physical assets, which is why this approach is usually attributed to firms foreign to the mobility sector, new to the market, and hailing often from data-driven backgrounds – the likes, in other words, of Google or Facebook. For the optimal provision of this type of service, however, such intermediaries are heavily dependent on the willingness of other companies to cooperate with them. With the rise of Uber, and service providers of its ilk, this procedure has usually been described as the 'uberization' of services.

As is often the case, a strict separation of the two procedures is not always possible – or, if possible, not always sensible or realistic. It is perfectly conceivable, for example, that what were primarily asset-driven companies are at present radically reinventing and transforming themselves into more data-driven companies with a drastically reduced inventory of assets. For automotive companies in particular in their striving towards servitization, a hybrid form of the two business models would seem to represent the ideal compromise. Such companies could

[13] We include in the category 'mobility service providers' all enterprises offering services for the transport of persons as well as those that, through the goods they produce and sell, enable personal mobility (e.g. car manufacturers).

seek, for example, to expand the range of services they offer, through the aggregation of other, third-party, suppliers. In this context, a dissolution of the link between the service *'mobility'* and the physical product *'vehicle'* might occur, calling into question the future core competence of a car manufacturer. [66]

In the light of the changes in customer requirements discussed earlier, the entry into the market of new, digital participants poses a challenge to established enterprises. New approaches will have to be found and services personalized through the use of new sources of data. However, the degree of this disruption, and thus the need for innovation, varies considerably between mobility companies. This is mainly due to the fact that the degree of competitive pressure, and the presence of the 'new' customer requirements to which companies are exposed, are strongly divergent. Car manufacturers and (full-service) airlines have been dealing with the personalization of services and the optimization of the customer experience for much longer – if only as regards the experience of their core product rather than that of the entire chain. Local public transport operators, on the other hand, have long focused on the needs of suppliers rather than those of users [67], as they would need to do to succeed in an 'open system'[14].

Digital companies from outside the mobility sector often enjoy an advantage here due to their backgrounds, having already acquired a great deal of customer-specific data and, with it, the ability to tailor their services far more closely to the preferences of their users. Internet companies such as Google and Facebook can access search and position data, for instance, that even today allow them to create highly detailed profiles of their users. Consumer surveys, such as that of *WINTERHOFF ET AL.*, have shown that users value considerably more highly their experience as customers of data-driven enterprises than of asset-driven enterprises. Consequently, the latter will have to call upon all their capacity to innovate in this respect, if they are to maintain their market position and not be relegated to the status of mere suppliers of transport capacities.

Logistics, too, is under enormous pressure to innovate. With the arrival of Uber Freight, the 'uberization' phenomenon is also spreading to this sector. The customer requirements already discussed have led to demands for ever greater transparency, flexibility and speed of delivery. This means that the final mile in particular, i.e. the actual delivery to the end customer, is posing ever greater and more complex challenges. It is not simply a question of respecting the individual preferences of the customer, but also of transporting ever smaller parcels, ever more swiftly, and in an efficient manner – and doing so in an environment of constantly dwindling infrastructural capacities and ever greater constraints (road closures, delivery time restrictions, ...). To overcome such constraints, logistics service providers must work together more closely and be orchestrated as a large, collaborative network. It is extremely likely, therefore, that additional logistics curators with few, if any, assets of their own will emerge, offering through their platforms an interface with the (end) customer. The Cainiao network in China, in which the Internet company Alibaba holds a majority interest, is another, already existing, example of the successful implementation of such a logistical platform-based ecosystem, currently overseeing some 57 million deliveries per day. [69] In the course of the Alibaba-initiated Global Shipping Festival on 11 November 2015, this ecosystem proved itself capable of coordinating more than 1.7 million parcel deliverers, 400,000 vehicles, 5,000 warehouses and 200 aircraft, in order to perform, in the course of 24 hours, some 467 million deliveries. [70] This further illustrates the potential, and above all the appeal, of logistics platforms. There are rising expectations, too, in the B2B sector as regards the synchronization of flows of information, material and finance, which could also be improved through the use of platforms.

It remains a fact, though, that the provision of mobility and logistic services requires a not inconsiderable number of physical assets that, from today's perspective with the advance of digitalization, could admittedly be greatly reduced in number but not easily replaced. So we cannot expect for the time being to see a complete restructuring of the market for mobility and logistics services. Furthermore, the start-up culture in Germany is

[14] 'Open system' refers to the system boundaries of data. Due to their current business structures, providers of local public transport have quite limited access to user data, whereas airlines know a great deal about their customers and their preferences.

heavily characterized by a mentality of acquisition at the earliest opportunity by established enterprises. So the risk posed to these markets by digitalization is primarily one of new entrants to the market appropriating the most profitable areas of the business, leaving established companies with the less profitable basic services or even to the simple provision of infrastructure and the requisite equipment. The danger then is that established companies will end up having to buy back at great expense the areas of their business surrendered – for simple want of in-house digital expertise – to the newcomers. That the cherry-picking has already begun is demonstrated by Fig. 6, showing the depredations wrought by start-ups upon the value chain of the logistics service provider FedEx. This makes clear the extent to which a host of start-ups have already occupied positions that traditionally formed part of the range of services offered by logistics providers. It is equally clear, however, that the interest of these start-ups is focussed on individual value creation activities.

It can also be assumed that competition will come from other areas, such as asset-driven enterprises from other industries. Autonomous heavy goods vehicles, for example, could soon be contending for large slices of the current haulage and taxi businesses. Manufacturers in this case could find themselves offering, on a variety of platforms, the capacities of their self-driving lorries in order to make maximum use of any available space. Only

Unbundling FedEx

Package, Envelope or Express Freight

›› Doormann
›› Parcel Pending
›› Roadie
›› Shipbob
›› Shiphawk
›› Shippo
›› Shyp

Freight Shipments

›› Cargomatic
›› Convoy
›› Keychain
›› Loadsmart
›› Pacejet
›› Transfix
›› Trucker Path
›› Uship

Expedited / Extra-care Handling

›› Bringsey
›› Boddytruck
›› Deliv
›› Dispatch
›› Flirtey
›› Kanga
›› Marble
›› Matternet
›› Postmates
›› Rickshaw
›› Schlep
›› Starship
›› Uber

Air / Ocean Freight Forwarding

›› Boxc
›› Fleet
›› Flexport
›› Freightos
›› Haven
›› Inttra

Fig. 6: Cherry-picking by logistics start-ups, taking FedEx as an example; source: [71]

recently Bosch, whose activities in the sector were hitherto confined to the supply of automotive parts, announced an ambitious plan to introduce driverless taxis in the year 2018 to German cities in collaboration with Daimler. [72] The vacuum cleaner manufacturer Dyson has also announced that it will begin manufacturing its own electric vehicles in 2020, and do so without any collaboration with automobile manufacturers. [73] Furthermore it is conceivable that autonomous vehicles operating in so-called 'platoon'[15] mode could encroach upon particularly profitable or in-demand routes within the local public transport network – as we are seeing already in the case of long-distance rail and coach routes. Car manufacturers in the high-volume segment could exploit their 'first mover' advantage and the de-emotionalization of cars to occupy large parts of the emerging market for such applications.

This further emphasizes the need for companies to be constantly refining and expanding the services they offer and striving to bind their customers to them through ever-closer contacts. More contact with end-users means more information about their preferences, which is of crucial importance to the further development of the services offered by the enterprise, and even the determination of its future core competence (i.e. the timely switch to a new S-curve), thus ultimately to the assurance of its long-term profitability. It is also important to be constantly monitoring and evaluating new technologies, so as to be able to react in time to the ever more manifest, and more virulent, hazards of disruption.

2.5 Preliminary conclusions: the need for change and success factors of the mobility, logistics and transport of the future

The logistics, mobility and transport sectors and their participants are about to experience one of the greatest transformations of recent decades. The third wave of digitalization has reached the gates of the mobility enterprises and is calling the status quo drastically into question. Digital consumers are no longer willing to devote much time to the decision-making process, and expect a personalized range of services that accords fully not only with their lifestyles but also their other inclinations, preferences and limitations. They are carrying over such demands unfiltered to logistic and mobility services. Being viewed as of secondary importance, such services must be seamlessly integrated into the rest of everyday life, easily accessible and not dependent upon ownership of the equipment required for their performance. This includes a broadening of the classic range of services to include others, such as entertainment and location-based services. Parcel deliveries must become more flexible and exhibit a greater degree of involvement with the end consumer. Furthermore, there is a need for the development of innovative concepts capable of assuring swift and, above all, punctual delivery in the context of increasingly overstretched infrastructural capabilities. In other words, even greater consideration must be given to the end consumer in every corporate decision.

With the fusion of the virtual and physical worlds and the trend towards the servitization of regular products, the quality of the customer experience will prove a decisive success factor or competitive advantage. However, this presupposes a paradigm shift in the relationship between enterprise and customer that will bind the latter more closely to the former. Where, in the past, the task was primarily one of selling products or services, in the digital age it is more a matter of counselling customers and supporting them proactively in the decision-making process. So there has to be a transformation of sellers into advisers, to ensure that customers perplexed by the 'paradox of choice' are plied with wise counsel. Thus, the current approach of customer-centric management, which is at present heavily based on the principle of customer relationship management (CRM), must be extended

[15] 'Platooning' denotes the formation of a networked convoy in which the first vehicle assumes a leadership role and guides those that follow. The optimum distance between the vehicles is maintained through the use of sensors and communication between the vehicles themselves.

to include the dimension of customer experience management (CEM). This is all the more true in the light of changing expectations and the ongoing general trend mentioned earlier towards purchasing results rather than purely products: the ‘outcome economy’. So future needs as well as possible changes or disruptions must be anticipated at an early stage and proposals for solutions offered proactively. At the same time, customers must be involved earlier and more closely in the decision-making process.

In order to expedite such an internal paradigm shift, digital expertise, e.g. in areas such as big data analytics and the integration of very different data sources and their analysis, are of essential importance. The current wave of digital disruption makes access possible to a very wide variety of data that can drastically improve not only the personalization, but also the planning and reliability, of services. Therefore it is of crucial importance for enterprises to find new ways of accessing and using such data. Currently, it is the former that is proving a particularly stiff challenge for enterprises in the logistics and mobility sectors. If you look at the enterprises already in a position to offer highly personalized services, you could argue that such companies are operating in a kind of closed system. Airlines know, for instance, where at any given moment their passengers are within their system, the point of departure and destination of their journey as well, perhaps, as their eating preferences and preferred medium of entertainment. It is much the same story with purely digital enterprises such as Google. By collating such information as search terms and locations entered by their users, companies like these have a comprehensive insight into their tastes and interests. For primarily asset-driven logistics and mobility enterprises it is therefore important to switch from a more open system to a closed one, in order to find out more about their customers. To this end, new data sources must be opened up and as much transparency as possible imparted to all processes.

For all areas of the enterprise to enjoy effective access to this data, the data itself must be democratized and a ‘single point of truth’ established, this being a prerequisite of a company’s successful transformation into a data-driven enterprise. By linking a very wide variety of data sources, operating processes can be made more efficient and agile, and new services, such as predictive maintenance (in the case of vehicles), offered as part of an enterprise's servitization efforts. Moreover, considerably greater data support must inform (operative) decisions, to meet the new logistical challenges of the ‘omni-channel’[16] age. At the same time, collected data in general represent an important asset for the digital age, as they make it possible to detect trends in consumer behaviour as well as supporting the generation of new services.

Such support is a particularly decisive factor in assuring economic viability in the digital age. With the constantly increasing speed of technological change and the increasing danger of disruptive innovations, logistics and mobility service providers must expand their innovation and research capacities so as to be able to identify potentially disruptive trends. In other words, companies must be sufficiently alert to recognize the right moment for a change in their own core competences (in the sense of inaugurating the next S-curve) or else fall victim to the Nokia-Neckermann-Quelle effect. With change the only constant, it is only a matter of time before the next wave of digital disruption – as to the possible effects of which we are still completely in the dark – falls upon us. Already we have seen the lowering of entry barriers (courtesy of technological progress) and the effacement or redrawing of boundaries between industries. Enterprises are being ever more frequently called upon not only to contend with direct participants in their respective markets but also maintain their competitiveness in the face of enterprises adopting a completely different approach to satisfying the same customer needs. The cruelly decimated market for digital cameras and the now virtually inexistent market for dedicated navigation devices are just two examples of the havoc wreaked by marauders from other markets.

What will influence consumers, enterprises and local authorities alike are the increased, and still increasing, strictures imposed on mobility and logistics suppliers in the interests of sustainability. To contend proactively

[16] ‘Omni-channel management’ describes the coordination with one another, and linking, of all existing sales channels and customer contact points within a company. All channels interact with one another and the customer can choose freely between them. This ensures that the customer experience is as consistent as possible.

against public nuisances such as greenhouse gases, environmental health risks, noise and higher accident rates, there will be steepening increases in both personal mobility budgets and the costs of providing services. These will impose multiple burdens on logistics and mobility enterprises in particular, as their customers will pass on to them the task of coming up with more sustainable alternatives, in order to reduce their own exposure to sustainability taxes. The upshot of this will be that, on the one hand, industrial customers will impose restraints regarding sustainability upon logistics service providers, in order e.g. to attain their own emissions reductions targets, and on the other, consumers will demand more from vehicle manufacturers – in order, for instance, to reduce the burden of their own mobility budgets. If such companies are to assure the future loyalty of their customers as well as the cost-efficient provision of logistics and mobility services, more environmentally friendly propulsion technologies will have to be employed. Preparations must also be made for the introduction of other emissions reductions tools, such as emissions trading along lines similar to the scheme currently being essayed in the world of aviation.

In line with a holistic approach to sustainability, infrastructure, equipment and future logistics and mobility services themselves must also pay greater attention to the social dimension of sustainability to avoid individual members of society experiencing exclusion. The concept of 'universal design' must become one of the guiding design principles of Logistics & Mobility 4.0. Greater thought must also be given – especially in the area of traffic control – to making efficient use of existing resources. This might involve, for example, the introduction of congestion charges – perhaps linked to the level of occupancy of the individual vehicle. Especially in view of increasing urbanization, the allocation of (infrastructural) resources poses one of the greatest challenges for future traffic systems.

Mobility, logistics and transport must, and will therefore, coalesce into a single system largely characterized by the continuous exchange with one another, and perpetual motion, of all the elements within it (such as data, people, goods and finance flows) – a state akin, in other words, to hypermotion.

Abstracting from the preceding paragraphs, seven elements emerge that need to be in place before this transformation of logistics, mobility and transport into a hypermotive transport system can be realized:

›› new sources of data must be opened up (Connectivity)
›› the system itself must be closed and data democratized in order to achieve complete transparency (Monitoring & Transparency)
›› decisions must be taken and new services developed on the basis of data (Data Analytics & Security)
›› the system must be geared towards greater sustainability (Sustainability)
›› logistical processes must be integrated into the everyday lives of consumers (Synchronized Logistics)
›› efficient use must be made of limited capacities in urban areas (Smart Regions), and
›› everything must be available, at all times, everywhere (Hypermodality)

In conjunction with the three dimensions required for the provision of logistics and mobility services, these yield a kind of grid mapping the DNA of future transport systems. The grid shown in Fig. 7, which also schematizes the DNA of the new trade show 'Hypermotion', is described in greater detail in the following chapter.

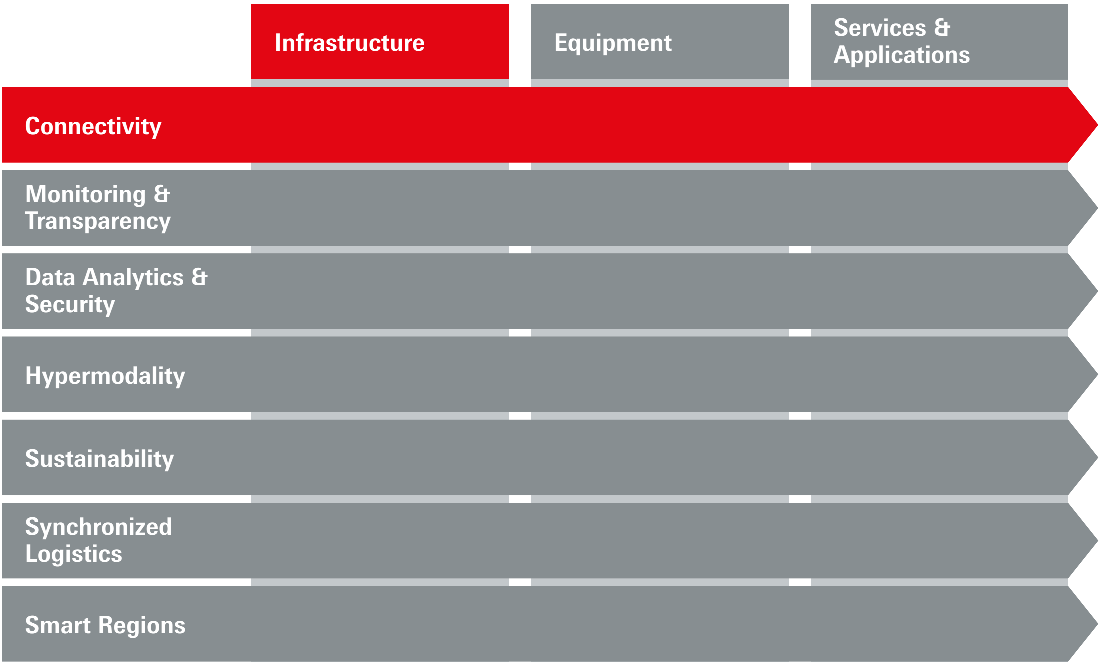


Fig. 7: The Hypermotion Grid – elements of future transport systems; Source: the authors

3

THE HYPERMOTION GRID – THE DNA OF DIGITAL TRANSPORT SYSTEMS

The response to the new complexity introduced by digitalization and the product and service disruptions it brings with it will be based on a network structure described below as the 'Hypermotion Grid'. The participants of such a structure will be means of transport (assets), enterprises, local authorities and citizens. The following chapter describes the Hypermotion Grid and its components in detail. Even if the construct is notable for the interconnectivity or interdependence of its individual components, the chapter is structured in such a way that the elements described earliest can be regarded as preconditions for those in the grid that follow.

3.1 Connectivity

3.1.1 Networking – the prerequisite of the digital transformation

Connectivity forms the foundation of digital mobility and logistics and represents the interface between the physical and virtual worlds. This dimension therefore includes everything relating to the so-called 'smartification' of objects, buildings and infrastructure as well as other elements of digital transport systems. By smartification is to be understood the enhancement of existing elements inter alia through the addition of sensors armed with particular capabilities; these are shown in Table 2.

Core capabilities	Capability	Description
	Digital identification	The ability of the object to gain access to information and make its presence in the digital context known.
	Retention	The ability to store information about itself and its environment – or at least its own identity.
	Communication	The ability to exchange information with other objects or people (e.g. via RFID).
	Energy harvesting	The ability to derive from external sources, or generate autonomously, the energy required for operation.
Optional capabilities	Processing	The ability to execute fixed or variable instructions and tasks or process them in the background.
	Sensing & actuating	The ability to measure (e.g. via sensors) values within their environment and influence it or other objects on the basis of such measurements.
	Environment awareness	The ability to take note of its own contextual environment (e.g. by collecting data of other objects) to improve its own performance.
	Social readiness	The ability to form social relationships within the network with other objects or persons.
	Networking	The ability to link up with multiple communication networks and support multiple standards.

Tab. 1: Capabilities of Smart Objects according to Hernandez and Reiff-Marganiec [74]

The idea of networking transport systems is nothing new, having for some years formed part of the concept of *Intelligent Transport Systems (ITS).* At its core, the ITS concept is concerned with the use of modern and emerging technologies in the context of transport systems. The use of different types of sensors to upgrade conventional objects to 'smart' ones makes it possible to record new parameters that serve as input factors for the improvement of operational processes and the development of new services. However, connectivity is not specific to digital logistics and mobility systems, but forms the foundation of the 'Internet of Things' (IoT) in all areas affected by the current wave of digitalization.

In the digital transport systems of the future, not only vehicles but also roads and rails (or parts thereof) are equipped with sensors that perform several functions at the same time. They record inter alia their current load, status and maintenance requirements and pass on this information to their operators and users. At the same time, things like video bridges collect information about vehicles, the current traffic situation, the utilization of vehicles and other attributes, such as their proper registration. Improperly parked vehicles and other objects liable to disturb the flow of traffic are also identified (important for autonomous vehicles). One of the cornerstones of connectivity is the exchange between these different objects and layers of a digital traffic system. The concept of machine-to-machine (M2M) communication has therefore a decisive role to play. M2M communication describes the automated exchange of information between technical systems like vehicles and machines, which are then welded by this constant exchange into an intelligent system of unlimited complexity. [75] This is essential primarily to improve the flow of traffic in the transport systems of the future, as M2M communication forms the basis for the creation of a central system responsible for controlling the traffic flow.

Smartified buildings represent a further component; these, too, taking advantage of a variety of sensors, are capable of providing information on their status and spare capacity. Although theoretically all buildings are capable of becoming smart objects, four types are primarily relevant to digital traffic systems: public transport access points; multi-storey (and other) car parks; warehouses and production facilities; goods handling areas, such as ports. Through the use of positional data and video surveillance, it is possible to ascertain not only the occupancy or spare capacity of coach and railway stations but also the general ambience within such buildings, which can lead to the prevention of acts of violence. Car parks, too, can share information on their spare capacity.

Especially in the field of supply infrastructure – such as warehouses, ports and production facilities – the increasing use of sensors will bring about considerable improvements in the optimization of capacity utilization and the orchestration of logistical activities. In a manner similar to traffic systems as a whole, all the elements of buildings such as factories are in communication with one another. Fork-lift trucks share information on their routes; load carriers and containers can be localized at all times and provide additional information on the state of the goods in their custody. The flow of materials can be self-governing through the application of swarm intelligence, as each load carrier knows at all times its own point of departure, destination and status. Developed by the Fraunhofer Institute for Material Flow and Logistics (IML), the 'inBin' already exemplifies such an intelligent container. The inBin can determine its own location independently, communicate with other containers and persons within the system, and take care of its own needs through energy harvesting.

Through synchronization with the position of the heavy goods vehicle designated to transport the load, the production and order-picking or stock transfer processes can be directed automatically. Outside production and storage facilities, intelligent load carriers can react immediately to anomalies in transit, such as the exceeding of temperature limits and violent shocks, but also to any unauthorized departure from the planned route or designated location. This achieves on a small scale what the Hypermotion Grid does for the transport system as a whole.

Already relatively intelligent, digital traffic systems are set to become still more so, with vehicles of all kinds bristling with sensors, exchanging information permanently with the infrastructure as well as other road users, and able in consequence to move independently and autonomously. This makes new ways of controlling the flow of traffic possible and could even make traffic lights, road signs and the like redundant. Researchers at the Senseable City Labs of the Massachusetts Institute of Technology (MIT) have been looking in some detail at this question and have already developed a theoretical concept or control algorithm to banish traffic lights from modern transport systems. [77] Already today, telematic systems are being used – on motorways in particular – to adjust speed limits continuously to the volume of traffic. It is therefore probable that digital traffic systems will make greater use of the principle. Thanks to the permanent contact and continuous exchange of information between the vehicle and infrastructure, instead of necessarily being displayed by telematic systems, the information could simply be transmitted directly to the driver's dashboard. At the same time, self-driving vehicles are able to adjust their speed automatically to the prevailing speed limit. Intelligent vehicles are also self-sufficient. Whenever their energy reserves require replenishing, they can locate and make their way automatically to the nearest filling station or charging point. The payment process for things like congestion charges can also be automatized (see Chapter 3.3, Data Analytics & Security). Furthermore, intelligent vehicles can recognize the current user and know his or her preferences and destination. Thanks to the spread of NFC chips[17] and geofencing (positioning and information exchange in the broader sense), payment for the use of local public transport networks can be contactless and based on the distance actually travelled.

At the same time, such information can be used to provide users with information about the number of spare seats on the next train, for example, or possible delays.

For this to be possible, however, connectivity must not end with the system itself. Users, too, must also be constantly exchanging information with vehicles and the infrastructure. For this reason, the interaction and communication between men and machines will play a decisive role in the networking of logistics and mobility systems. Since the introduction of the smartphone, more and more intelligent or smartified objects have been entering our daily lives, shedding light on a multitude of everyday needs; and these – integrated into intelligent transport systems – could unleash further synergies. For instance, purchases could be included in the route planning dynamically. Parameters reflecting the subject's current state of health could influence the personalization of services. A smart watch or Fitbit, for example, having detected an increase in the wearer's body temperature, might notify the vehicle, or even, on its own initiative, turn down the air conditioning; having picked up symptoms of 'micro sleep', it might issue an alert. Through the use of nanophotonics[18], if the health parameters give any indication of irregularities, the vehicle itself could take over and drive the subject directly to the nearest hospital or first aid station.

Of course, the described innovations and applications for sensors can only be realized if the infrastructure required for the transmission of data is constantly expanded and kept abreast of the state of the art and the devices integrated into a network. We have seen for some time now a steady increase in the demand for broadband, but steeper increases are to be expected with the continuous expansion of the IoT. According to a CISCO forecast, global IP traffic, which in 2016 was about 1.2 zettabytes[19] (ZB) worldwide, will increase to about 3.3 ZB by 2021. [79] The average rate of increase between 2016 and 2021 is expected to be around 24%. Therefore it is urgently necessary for broadband networks - both fixed and mobile – to switch to fibre-optic technology as well as making available the mobile frequencies required for the introduction of the successor to the LTE standard, 5G. Furthermore, net neutrality must be preserved, so that small and medium-sized enterprises (SMEs) can also play their part in Logistics and Mobility 4.0.

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[17] 'Near field communication' (NFC) is an RFID-based data exchange standard governing the contactless transmission of data by means of induction.

[18] The enterprise Qi Nanophotonics uses inter alia the light emitted by bodies in order, for instance, to determine a person's state of health, but also to generate a biometric encryption (quantum identity). [76]

[19] 1.2 zettabytes is equivalent to about 96 exabytes (EB) or one billion gigabytes (GB).

3.1.2 Core theses on connectivity in digital transport systems

> Smartification: Buildings, assets and vehicles will be fitted with sensors and data transmission equipment and able to provide information in real time on their status, load capacity and environment influences.
> Communications: Through the use of machine-to-machine and machine-to-person communication, as well as free access to mobility data, it will be possible for autonomous vehicles to be controlled by a central guidance system. Speed limits will be set dynamically, based on the current volume of traffic. This will lead to the gradual disappearance of road signs and traffic lights from traffic systems and the submission of anonymized mobility data (e.g. concerning the vehicle used) will be compulsory.
> Prioritization: With logistics and mobility making up the central nervous system of cities and regions, such data as is required to govern the flow of traffic will be given priority for transmission purposes. By these means, the steady flow of traffic will be assured.

3.2 Monitoring & Transparency

3.2.1 Transparency the key to digital excellence

Connectivity makes accessible a host of new data sources providing information on mobility, logistics and traffic that were never before available on a like scale. Of course, for these to be used effectively, *all such sources of information must be connected in a rational way that ensures consistent visibility across all processes as well as within the logistics and mobility systems as a whole.* The success factor Monitoring & Transparency provides just that: as a basis for area- and enterprise-transcending analyses and processes, not only internal but also external data sources must be made available from a central source: the *'single point of truth'*. This presupposes the design of uniform data models and indicators that serve as associative factors between the various data sources. Data only attain transparency when they speak a common language.

Monitoring & Transparency provide essential support for decision-making in traffic control but also ensure the quality of traffic management. The output of both logistics and mobility, traffic comprises the total flow of goods, people and data in smart cities and regions. Suboptimal control of this flow will have even more disastrous consequences in the future than those already to be observed in today's traffic systems. Traffic control centres will therefore play an even more important role and develop into key factors in the successful management of the traffic systems of the future. For this reason, particular attention is being paid to Monitoring & Transparency in the public sector at both federal and state level. Overall, city councils will assume a prominent position in data management, as they enjoy a higher level of public trust than, say, US corporations based in sunny California. In logistics and supply chain management, the concept of 'supply chain control towers' has been around for several years, these being seen nowadays as prerequisites for agile and resilient control of globally fragmented supply chains (SCs). With a functionality loosely modelled on that of an airport control tower, SC control towers are charged with bringing the greatest possible transparency into the entire value creation network and taking operational decisions quickly and reliably using such techniques as 'what if' analysis. This approach is already very similar to that of proactive traffic management and will be perfected by exploiting the newly acquired connectivity of logistics and mobility systems.

Traffic control centres will be assigned to smart and digital regions, the boundaries of which will not necessarily correspond to those of today's federal states (see Chapter 3.6, Functional geography), as they develop. Thanks to the connectivity-assisted transparency that will characterize all infrastructure in the catchment area, as well as the users or means of transport underway therein, the traffic flow will be controlled flexibly, with key performance indicators – such as strain on the infrastructure and average journey duration, but also regional pollution levels – all taken into consideration. Furthermore, additional information sources from external data vendors will be integrated, in order, for instance, to allow forecasts to be made about the influence of changing weather conditions as well as major events and their likely effects. Other important items of data, of which traffic control centres to date have been unable to avail themselves, are the starting point and intended destination of each journey. With increasing levels of automation, autonomous vehicles will consult traffic management systems as to their best possible route, thereby providing additional input for the dynamic control of the traffic flow in smart cities and regions. Armed with this information, the traffic control centre will switch roles, going from purveyor of recommendations to genuine capacity allocating instance in real-time (Control).

Above all in urban centres, the available infrastructural capacities will be allocated to vehicles as they register and road lanes assigned to each based upon its stated destination. Where logistics service providers have given notice in advance of scheduled delivery runs, the traffic control system will already have factored this information into its calculations, and, nearer the time, will determine their best routes and allocate the requisite lanes. Charges incurred for the use of the inner-city infrastructure will be flexible and adjusted through 'surge pricing' to take account of the actual and forecast volume of traffic. Furthermore, the traffic control centres of the future will not only proactively control traffic but also offer individuals advice as to which is likely to be the quickest, and which the cheapest, way of reaching their respective destinations. If, for example, there are no parking spaces available or the roads can carry no more traffic, alternative suggestions – such as ride-sharing, using public transport or postponing the journey altogether – will be proffered. Such suggestions will be communicated to both private individuals and mobility curators, and their acceptance incentivized as a means of reducing the incidence or severity of bottlenecks (see Chapter 3.7, Loyalty programmes).

It is not only traffic control centres that will make use of the control tower concept. Transport associations and other providers of local public transport could adopt the same approach and manage the operative control of their own businesses dynamically in a manner similar to that of the traffic control centres. Once they know the individual destinations of their users, they will be in a position to tailor the routes of busses or shuttles to the actual demand. The price charged could also reflect the level of demand or occupancy of the vehicle in question as well as the exact distance travelled.

Data in digital transport systems and smart regions are democratized and made at least partially accessible to citizens, businesses and town councils in the interest of optimising the overall flow of traffic within the system and letting other companies that depend on mobility and logistics share the information. The control towers of individual businesses will be permanently connected to the 'Internet of Mobility' of their respective regions. The relationship of all elements within the system will be one of give and take: to obtain access to, or information concerning, the current traffic situation within a smart city, you will have to feed in – albeit anonymously – information from which it will be possible for your own prospective contribution to the volume of traffic to be inferred.

3.2.2 Core theses on Monitoring & Transparency in digital traffic systems

Single Point of Truth: Data sources of different types are made available in a central location using a common, standardized 'data language'. This creates total transparency across entire transport systems, thereby supporting the fleet management and route planning of logistics and mobility companies.
Control tower: The traffic flow of a region or city is monitored and controlled proactively from a control tower. In the process, the tower changes from being a mere purveyor of recommendations to a genuine capacity allocating instance. To make this possible, city centres will be the exclusive preserve of autonomous vehicles. Companies, too, will apply the control tower principle to optimize their supply and disposal processes. Due to the increased demand for integrated control tower solutions, the business model of the supply chain coordinating 'fourth party logistics service provider' (4PL) will see a revival.
Data Democratization: Data in smart regions are for the most part democratized and can be accessed by every citizen, every local authority, and every enterprise (Open Data Principle). This will enable the entire mobility and logistics system to be optimized by the enterprises participating, which in turn will lead to improved transport connectivity for those people and enterprises that rely upon efficient logistics and mobility.

3.3 Data Analytics & Security

3.3.1 Personalized, reliable and secure transactions in the digital ecosystem

As we have mentioned, Monitoring & Transparency are matters of keen public interest, as without them the free flow of information into the digital traffic system is likely to be constricted. The activities encapsulated by the term 'Data Analytics & Security', on the other hand, are more commercially oriented. *The most urgent task is the design and development of the means of conducting personalized, optimized and secure transactions within the digital transport system.* As the digital ecosystem, consisting of highly specialized companies working closely together to provide services to end customers, develops, expertise in areas such as data analytics will be among the most critical core competences, and secure, manipulation-free data exchange, a basic prerequisite. In the domain of logistics, mobility and traffic, data analytics has two main applications. On the one hand, advanced analytics can be used to improve operational and tactical commercial processes for the provision of services or the production of goods. On the other, data analytics can play a key role by informing: first, the personalization of products and services in line with the end user's predilections; then, the detection of new needs – ideally before the user in question is even aware of them. This shows the interdependence between this success factor and the one (Monitoring & Transparency) described in the previous chapter, upon whose efficient linking of multiple data sources data analytics relies, and without which it might be impossible to conduct the relevant analyses at all.

The higher expectations placed on logistics and mobility services in the digital age call for fortified operational resilience. In the case of heavily asset-intensive industries, this means above all improving and guaranteeing their availability. The provision of new types of information by smartified assets and the use of data analytics will make it possible to monitor and assess continuously the state of vehicles, for example, to avoid unexpected breakdowns. Through the use of 'deep learning', such analyses will become increasingly predictive so that the need of a vehicle for maintenance can be anticipated and even pre-empted – by recommending, for example, that such and such a part (which was about to fail) should be changed. Such analyses should, as far as possible, be domain transcendent, so that maintenance decisions can be guided by an understanding of their implications for the overall opportunity costs of the enterprise.

With the comprehensive adoption by enterprises of platforms upon which to offer their services, operative planning becomes increasingly complex, and optimal implementation dependent upon the adoption of a higher degree of automation (e.g. through the use of machine learning, deep learning systems and artificial intelligence). Enquiries and orders for services or capacities arrive via a variety of channels and have then to be bundled in a sensible fashion to arrive at the overall optimum result – e.g. the shortest overall journey or delivery time. By defining warning parameters, enterprises will be able to anticipate and minimize potential interruptions in the operational environment, as well as estimate their impact upon their own operations and those of the companies downstream. Such idealized planning presupposes a high degree of vertical integration, through a variety of interfaces, of digital logistics and mobility chains – at least where the exchange of planning data is concerned. Only in this way will it be possible to offer the end user a seamless, multimodal and integrated transport chain, as well as a practical alternative swiftly should some unanticipated contingency shove a spoke in the wheel. On the control tower principle expounded above, these (Plan A and Plan B) will be furnished by a curator with oversight over the entire mobility chain and forming the principal interface to the customer – as well, in most cases, as providing, securing and controlling the platform itself. The curator permanently monitors the planned departure and arrival times of the means of transport involved and calculates, based on the current position of the user, various alternative scenarios in the event of the latter missing the departure of the conveyance booked.

This, in turn, gives rise to a fundamental change in the planning of routes and timetables in local public transport (and other) networks. In digital transport systems, these are considerably more flexible and constantly revised – at weekly or monthly intervals – as new user data becomes available. In addition, the positional data of users allows the precise occupancy level at any moment of vehicles within the public transport network to be determined. Such data accumulated over time can be used to predict demand. In the same way, logistics companies can detect bottlenecks faster and more effectively and allocate or expand their existing capacities accordingly. The forecasting and planning of required transport capacities can be supported by additional data sources, e.g. by deriving correlations between clusters of search engine queries or expressions of interest on social media platforms and an increase in the demand for the company's own services.

As mentioned above, data analytics also creates considerable added value in the development and personalization of services and can be used to guide the evolution of the core competences of enterprises – i.e. to ensure their continuing relevance to the market. The digitalization of a large number of everyday transactions, e.g. the booking of mobility services, enables enterprises – if able to access and process the information intelligently – to obtain a more holistic picture of each individual customer or user; and this in turn allows them to segment and address their customer base much more efficiently. From their order histories, for example, mobility service providers can detect not only a user's preferred means of transport but also the journeys they make most often (e.g. commuting to work) and their habitual times of departure. The same data can be used to warn customers earlier of delays or obstructions affecting the routes in question and perhaps suggest alternatives. Users who set store by a quiet ambience can be warned if their usual coach or compartment is likely to be packed, and 'upsold'[20] a first class ticket perhaps, or advised to delay or bring forward their journey. Such data can also be used to facilitate and optimize deliveries, synchronizing delivery times to assure wherever possible effective delivery of the goods. This does not necessarily mean their delivery to the recipient in person (see Chapter 3.5, Synchronized Logistics).

What it does require, however, is the existence within the digital ecosystem of a means of assuring the secure and automatic exchange of data between customers and businesses (or between businesses) and a similarly secure and automated means of making payments. It is therefore highly likely that the blockchain principle will become established as a standard, to ensure such data exchanges cannot be intercepted or interfered with. Known to most as the technology underlying the Internet currency 'Bitcoin', blockchain not only makes it possible to prevent the corruption of information by third parties but can also guarantee the secure conduct of (monetary) transactions. Collaboration contracts and payments for services rendered are validated by all parties concerned via

[20] 'Upselling' is inducing the customer to purchase some higher-value service or product than the one to which they are currently entitled.

a decentralized network, thereby obviating the risk of irrecoverable data loss in case of local system failures or cyber attacks. And all this is accomplished without recourse to middlemen! Blockchain provides a means whereby flows of information, material and money can be coordinated, paving the way in tandem with the Internet and IoT applications for a major disruption of many logistical processes. The travel company TUI, for example, uses blockchain technology to track the availability of beds in real time, the information being reserved at present for internal use. [80]

Assimilated into the design of logistics and mobility chains, blockchain could bring increased planning efficiency and enable the real-time monitoring of network load. Transport and warehouse capacities can thus be made transparent in real time, with automatic advance allocation, and billing on the basis of current demand. By the same token, freight documentation can be simplified (e.g. by eliminating subcontracts) and linked to payment and customs declarations of consignments and transport services.

The use of blockchain also enables the incorruptible storage of data regarding things like the production of goods and services. Raw materials can be traced to their place of origin and an ineradicable record made of the emissions generated in the process, as well as of any modifications to the goods themselves. This not only allows more precise monitoring of the time and cost of individual steps in the process, but also optimizes the balancing of emissions, as well as making it possible to ensure the authenticity of 'fair trade' products . Applying the same technology, the IT and consulting company IBM has teamed up with the start-up Everledger to make the origin of diamonds traceable and thus reduce the spread of so-called 'blood' and 'conflict diamonds'. [81]

End users themselves will be able in the future to employ blockchain-based solutions to budget their available income and automate payment processes. They could, for instance, allocate specific sums to specific categories of expenditure, and then delegate to smart objects authority to make appropriate payments, provided the budget of each category is respected. Just such an object is the 'eWallet' developed by the automotive supplier ZF Friedrichshafen, which permits holders to automate the payment process when charging their electric vehicles. [82] This ensures that the defined budget – e.g. for mobility – is not exceeded but with the added convenience of automating the payment process. Furthermore, the concept allows the simultaneous validation of both the user and the transaction. In the context of digital transport systems, this can be used to verify bookings within mobility chains among the companies involved and, should the need arise, to transfer bookings from one service provider to another. This also optimizes and automates the payment process between private individuals, e.g. when one takes up the other's offer to share a ride. One day, every citizen will have a kind of 'digital twin' – the point at which several such blockchain applications converge to generate for that person a validated digital identity. Complementing or perhaps supplanting traditional identity documents (e.g. registration certificates, photocopies of ID cards, severe disability certificates, etc.), this digital identity can be fleshed out at will (by including or linking to further data sources) with matter such as Schufa credit ratings, profile evaluations on platforms such as Uber or Airbnb, bank details and crypto currency deposits. The 'digital twin' also affords a basis for the design and booking of individual mobility services.

3.3.2 Core theses on Data Analytics & Security in digital transport systems

Prognoses: The newly acquired data transparency together with the acquisition of expertise in data analysis make it possible for companies to increase their operative resilience, as well as recognize the needs both of their customers and of their own assets even before these manifest themselves. Predictive maintenance, demand sensing and real-time scenario analysis help to make this possible. Transport capacities become more malleable and adapt to the actual demand, whilst timetables and fixed routes are updated and optimized at least once a week to reflect changes in demand. At the same time, fleets partly manage themselves, by decommissioning vehicles at the optimum time to allow maintenance work to be carried out. Furthermore, the segmentation of customer requirements extends down to the level of the individual, which involves the drawing up of detailed profiles of both mobility and ordering behaviour.

Alerting: Early warning systems will help companies to identify disruptive factors in their supply and transport networks more quickly, so that they can take countermeasures in good time.
Blockchain: Blockchain can become the backbone technology of Logistics & Mobility 4.0 and give every citizen a secure, validated, and digital, online identity capable of serving as the basis for all transactions within the digital ecosystem. Furthermore, it could underpin the massive simplification, speeding up and automation of documentation and payment processes. Through the confluence of material, information and financial flows, logistics processes become simpler. Capacities can be monitored in real time as well as planned and billed automatically. In addition, the origin of raw materials and any changes to them can be documented without fear of manipulation, thereby helping to stem the flow of raw materials from conflict zones.

3.4 Sustainability

3.4.1 Sustainable mobility and logistics in all three dimensions

With Sustainability, this chapter reaches the first success factor that is not merely based on the preceding design parameters but can only be achieved in its fullest dimension in conjunction with all the previous elements of the Hypermotion Grid. At the same time, sustainability is one of the dimensions that will influence the end user and the company equally. According to the weighted pillar model presented in Chapter 2.3, the sustainability focus of digital traffic systems will be increasingly upon the ecological dimension, which forms the basis for the holistic sustainability of the entire system. The demand for corporate sustainability will be driven massively by pressure from end users.

The enormously increased transparency exhibited by the flow of goods and people will permit the implementation of a hitherto too complex system of taxing and trading climate-relevant greenhouse gases, so that socialization of the public costs becomes possible. It is conceivable that – analogous to the emissions trading seen in aviation since 2012 – regional taxes will be imposed on both private individuals and enterprises based upon the emissions produced or occasioned by them, whether directly or indirectly. Comparable to the quota system for waste disposal enforced by some local councils in Germany, private individuals and enterprises will each be allowed a certain quantity of emissions they can consume or emit free of charge each year. Following the example set by aviation, this quota will be gradually reduced, in order to bring about a lowering of the overall volume of greenhouse gas emissions. The speed at which people consume their quotas will depend upon the decisions they take: as to the type of vehicles they use, the services of which they avail themselves, the orders they place and their manner of delivery, but also as to the products they purchase in the supermarket. Residual quotas can be traded via central platforms at prices determined by supply and demand. It will also be possible for individuals and enterprises to reduce their emissions tax liability through carbon offsetting[21]. So the influence upon the environment will be a determining factor in the choice of mobility service providers and vehicles in digital transport systems.

In attempting to meet the new challenges, service providers in particular are subject to dual constraints: they must not only control the size of their own carbon footprints but also offer mobility services that subject the emissions and mobility budgets of their customers to as little strain as possible. In digital traffic systems, congestion charging is dynamic and governed by things like current emission levels, noise pollution and the total energy consumption of the smart region in question. The congestion charges due – and therefore the cost of providing a

21 'Carbon offsetting' involves enterprises compensating for their own emissions by performing some kind of penance e.g. by supporting climate projects.

service – are also influenced by the types of vehicle used, their means of propulsion and their occupancy. Just as a list of ingredients must be displayed on the packaging of foodstuffs, it will be necessary to publish or otherwise make available to the user the degree of sustainability of each service. Using this information, mobility curators will be able to calculate the total overall cost to the end user of alternative mobility chains and propose the cheapest. With the incentivization of traffic rerouting by the traffic control centres responsible for smart cities and digital regions, curators have the added option of purchasing additional quotas. In line with the set quota for renewable energies, it is also conceivable that mobility and logistics companies will be obliged to derive from renewable sources at least 10% of the energy they consume or else face further taxation.

In digital mobility systems, end users and vehicle owners, too, have many ways of reducing their carbon footprints or the basis upon which their emissions tax is calculated. In addition to the above mentioned carbon offsetting, emissions liability could diminish in inverse proportion to the occupancy of the individual vehicle. The emissions resulting from a trip, for example, could be apportioned freely between all those in the vehicle.

One can imagine other incentives, too, such as the issuing of emissions credit notes to users settling for some less convenient means of transport or consenting to delay their departures (see Chapter 3.7, Loyalty programmes). Exceptionally environmentally friendly means of transport, such as bicycles or pedelecs, could thus be made even more attractive, thereby reducing the demand for individual motorized transport. Further incentive could be provided by making particular inner city areas the exclusive preserve of one, or several, types of conveyance, such as bicycles and/or trams.

One of the principal objectives of ecological sustainability in the transport sector will continue to be decarbonization. From the perspective of the current state of technological progress, electric mobility will play a significant role in the decarbonization of transport, but it alone will not solve the problem. Rather, digital transport systems will contribute to increasing the environmental sustainability of transport, mobility and logistics by enlisting a dynamic array of alternative propulsion technologies, the choice between which at any given time will depend upon the current load values of the smart city or region. In the inner cities, however, shared resources with electric motors will tend to predominate, as these are generally the preferred option for covering short distances. This will also help reduce the level of harmful pollutants such as NO_2 in congested cities.

As stated at the outset, the traffic systems of the future will need to pay closer attention to the social dimension of sustainability. Detailed user profiles, based not only on data submitted by users themselves but also on their booking histories or other data sources to which mobility curators are granted access, will be consulted in the planning and implementation of mobility chains, so that allowances can be made for any disabilities from which users might suffer. Furthermore, the digital twins of telematics-based traffic signs and directions will be relayed to things like navigation applications but displayed there in the user's mother tongue. Navigation functions like these will also take into account any physical handicaps from which the user might suffer as they guide them through access points to public transport such as railway stations. Persons whose limited mobility has hitherto prevented them travelling unaccompanied in motorized vehicles will benefit from the use of self-driving vehicles, which will give this user group a considerably higher degree of self-determination and promote social inclusion. Nuisances like noise and the constant vibration caused by rail traffic, along with the damage it causes to buildings, can also be recorded and factored in to the social costs incurred.

Greater use of autonomous vehicles will bring about a general improvement in road safety in urban areas. In can also be assumed that M2M communication will permit the existing infrastructure to be shared more equitably – and above all more effectively – between traffic participants, thereby eliminating or reducing the incidence of traffic jams. It is therefore conceivable that the greater accident risk posed by manually driven vehicles will be priced in to congestion charges as a quasi insurance premium; the precise amount of the surcharge, of course, would depend on the time actually driven manually. The success factors Connectivity and Data Analytics & Security in particular provide further opportunities for increasing the social sustainability of digital mobility and logistics. In response to sensors of the type already installed in some vehicles to detect the first signs of fatigue on the part of the driver, vehicles could switch to auto pilot in order to reduce the risk of accidents. By issuing them with 'smart glasses' (or the like) capable of detecting and warning of stress or tiredness, the safety of factory workers could conceivably be enhanced in the same way. In some areas, the science of nanophotonics could even be enlisted for the purpose.

3.4.2 Core theses on sustainability in digital traffic systems

Carbon footprinting/Decarbonization: Citizens and corporations will be assigned emissions quotas for greenhouse gases and pollutants and their emission documented or such documentation made mandatory. If quotas are exceeded, unless new certificates are acquired on the second hand market, the excess will be taxed. Companies must also provide reference values for the impact of their products and services upon the environment, in a manner similar to the display of nutrient information on foodstuffs.
Universal mobility: Universal Design will establish itself as one of the standard principles guiding mobility services and infrastructure. Mobility systems will automatically take into account their users' handicaps or disabilities.
Cost socialization: Not only emissions but other public nuisances such as traffic jams, accidents, vibration damage and noise will also be factored in dynamically to congestion charges. Whether vehicles are driven autonomously or manually will also be taken into account.

3.5 Synchronized & Urban Logistics

3.5.1 Value creation synchronized down to the tiniest detail

In an era characterized by the drastic acceleration of supply and transport chains, the success factor Synchronized Logistics will primarily nurture the prosperity of regions, cities and their inhabitants. Logistics will be more crucial than ever to the success of enterprises and regions. *Synchronized logistics means the coordination and orchestration of value creation activities worldwide – with no step in the process too insignificant to merit consideration – in the interests of the individual (end) consumer.* Its benefits are most clearly felt and its potential greatest in two areas: the production process and the digitalization-assisted negotiation of the final mile.

Industry 4.0, which can thought of as the product of the three success factors Connectivity, Monitoring & Transparency, and Data Analytics & Security, has as its goal the design of synchronized supply and disposal processes. The resulting lower production and transport costs and greater sustainability will permit production closer to the place of consumption or purchase, which is also necessary in the digital age to meet the increased demands on the delivery speed of (personalized) orders. One of the enabling factors, as mentioned earlier, is the proliferation of automated production technologies such as robotics. The increased use of a robotic workforce not only reduces the unit costs of the goods produced, but also enables round-the-clock production operations. In addition, the integration of logistics and additive manufacturing technologies (e.g. 3D printing or selective laser sintering) offers the possibility of a holistic optimization of value-added activities. The production of goods can thus be orchestrated centrally, but the performance decentralized. Whilst the design and production programme remains the central responsibility of one company, the actual production is carried out by various companies or participants. A large number of products and their spare parts can therefore be produced locally in actual production facilities using 3D printing, for example, and delivered to end customers more quickly – always assuming, that is, the latter do not elect to print them themselves at home or pick them up from a makerspace[22] or some-

[22] 'Makerspaces' are collaborative workspaces that are often designed to create rapid prototypes of design ideas. For this reason, they are often equipped with such equipment as 3D printers.

where of the kind. Production in the digital age will therefore be considerably more autonomous and conducted increasingly on an 'on demand' basis. This is especially valuable in major conurbations as a means of eliminating the rising costs of dwindling infrastructural capacities.

By facilitating the personalization of goods and efficient procurement of spare parts, additive manufacturing will prove overall a key technological advance. Not only services but also physical products will be increasingly customized and, in the case of items of clothing – such as shoes for example – to some extent made to measure. The final stages of production could take place in multiple locations depending, as already mentioned, on the preferences of the customer. Co-creation approaches, whereby designs are only finalized after input from the customer or user, will also be adopted more widely. When applied to spare part logistics, 3D printing not only economizes on warehouse space but also makes needed parts available more swiftly. Less complex parts can be printed and delivered relatively quickly, drastically reducing the downtime of machines and vehicles by eliminating, or considerably reducing, delays caused by supply bottlenecks. The logistics service providers UPS and FedEx are offering this type of service for replacement parts or custom implants with delivery the next day or within 24 hours. [83, 84] In this way, products give way to objects of the type designated 'spimes'[23]. Spimes are objects consisting mainly of metadata – that are therefore fully digital – but capable of having an unlimited number of physical incarnations. Spimes can be tracked through space and time throughout their entire lifecycle and the resulting data analysed, which should mean greater sustainability when applied to goods. [85] Every spime, as well as each incarnation of it, is assigned for this purpose a unique identification number, indelibly linked to the customer and every transaction involving it. This continuous monitoring is made possible by RFID chips and the like. The upshot, in the final analysis, is that manufacturers turn into software suppliers for their own products and increasing customization of the end product, as very distinct components from very different production locations can be used in its manufacture.

This also implies a concomitant shift in the types and volumes of freight. In the digital age, as a result of on-demand production and the relocation of value creation activities (so-called 'reshoring' or 'nearshoring'), it will increasingly be bulk goods (e.g. granulates) that are shipped to smart regions. There will be a corresponding reduction, as a result of digitalization and finalization of products by the end customer, in the volume of finished goods transported. Furthermore, the co-creation of products in collaboration with customers as well as the accommodation of individualization requests logically precludes production in advance or stockpiling of such items. All this notwithstanding, international freight traffic will still contribute significantly to the prosperity of smart regions, as the structure of the economy assumes a still more collaborative character. As with the traffic systems of smart regions, global value creation networks will be rendered transparent to all participants in the supply chain through the use of sensors and the sharing of data. Thanks to this greater transparency, suppliers will be able to synchronize their activities with those of manufacturers downstream, which means improved capacity planning and the large-scale shrinking of inventories (centralized coordination, decentralized execution). Moreover, early warning systems can be used to anticipate or report potential disruptions so that timely countermeasures can be taken. In addition, the application of advanced demand sensing methods that take into account correlations between comment in the social media and Internet searches, on the one hand, and product sales, on the other, increases the accuracy of sales forecasts and thus further optimizes the inventory situation of the entire network.

The changed ordering behaviour and limited infrastructural capacities in urban areas also necessitate innovative concepts for the provision of services in the final mile. Products the end user cannot or does not wish to print can be processed and prepared for various delivery options in urban handling centres, usually located on the periphery of smart cities or regions. With the spread of autonomous vehicles, an array of alternative delivery con-

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[23] The term 'spime' is a neologism formed by conflating the words 'space' and 'time' and is intended to underline the traceability through space and time of the objects to which it is applied.

cepts become feasible. Regardless of the possession or otherwise of an autonomous vehicle by the person placing the order, one can be used to collect it – either from one of the aforementioned handling centres or from some decentralized delivery location. Pick-up times can be arranged on the basis of synchronized logistics in such a way that – whilst the main priority remains delivery of the goods at the earliest opportunity to the end customer – a more holistic optimum plan is arrived at and a more efficient use of all the requisite (infrastructural) capacities achieved. This could conceivably involve shared autonomous vehicles picking up the current user's orders from one of these handling centres prior to collection. Or the user's own vehicle could do the same thing while he or she is at work or otherwise engaged. The system already tested in Germany and Sweden [86, 87] of delivery of parcels to car boots represents another concept that could be enlisted by digital traffic systems to negotiate the final mile. In communication with one another, the customer's vehicle and the delivery company could settle upon the optimal transfer location, on the basis of e.g. historical data regarding the position of the vehicle or through transmission of the user's calendar data. And, of course, the principle of car boot delivery can be applied to any door. The 'Amazon Key', presented by Amazon, offers delivery services a means of opening the recipient's front door and leaving the package inside. [88] This delivery is filmed and can be monitored by the recipient in real time via an app. For the efficient delivery of larger or multi-part deliveries, the expansion of stationary hand-over systems, such as parcel stations and parcel shops, is essential. This would have the beneficial effect of reducing delivery traffic, as it means a dramatic increase in the ratio of deliveries to tour stops.

It is also conceivable that drones and delivery robots could be employed primarily for the fine distribution of deliveries. Delivery vehicles no different from today's, for example, in densely populated areas could release a squad of robots to make simultaneous deliveries to customers in the same or neighbouring streets. Drones could be deployed for particularly urgent deliveries. However the capacity for such deliveries will be relatively limited and they would be reserved for deliveries that really were urgent – perhaps a matter of life or death. These might be life-saving medicines, or perhaps fairly small replacement parts needed for the repair of some vehicle. Surplus capacity would then be made available to the rest of the market, so that emergency deliveries could be transported to urban regions as quickly as possible. The picture would be different in less populated or hard-to-reach areas where greater use is likely to be made of drones. Perhaps here, too, conventional delivery vehicles, equipped this time with drones rather than robots, could be used to make simultaneous deliveries to multiple customers.

Such technologies will complement, however, rather than altogether replace, traditional means of delivery. The challenge of increasingly fragmented orders, succeeding at ever closer intervals, can and must be solved through collaboration in the digital age. On platforms like Flexport and uShip, logistics service providers not only offer and trade freight volumes and transport capacities but also exchange and reallocate them to ensure the highest possible utilization of their own assets as well as, where applicable, a reduction in congestion charges. The most valuable asset in such cases is information.

The principle of collaborative competition will for that reason guide the logistics of smart cities and digital regions. Private individuals can also be integrated into such platforms and offer their capacities for the transport of goods (see Chapter 3.7, Crowd Logistics). It is also conceivable that concessions for certain areas could be awarded to individual logistics service providers in order to assure the efficient supply of goods and collaboration among the service providers. To date, city logistics have always foundered on the same rock: the sheer abundance of data to be analysed and processed, but with digitalization and the spread of advanced analytics, the situation should improve. Synchronized & Urban Logistics is therefore a sine qua non of successful city logistics.

3.5.2 Core theses on Synchronized & Urban Logistics in digital traffic systems

Automation: Through the increased use of robotics, production becomes commodified and flexible, decentralized on demand. This will involve the relocation of some production facilities closer to the point of use. The production of goods in such cases will be centrally coordinated but decentrally implemented.
Orchestration: The pluralistic lifestyles of the digital age call for maximum flexibility when it comes to delivery options, with a high convenience factor in the final mile. Deliveries must be slotted in to the everyday life of the customer and delivery processes adapted to his or her habits. The various delivery options can be priced dynamically on the basis of the current demand and other circumstances, whether to generate additional revenues, reduce delivery traffic or maximize asset utilization. Drones and delivery robots will be conscripted so that multiple deliveries can be performed simultaneously in the final mile. In addition, the design of logistics networks will be informed by the principle of collaborative competition, underpinned in smart regions by the award of concessions to individual service providers.
Individualization: Not only services but also physical products will be customized – many of them will be one-offs, developed in collaboration with the customer. Companies become software suppliers and products become 'spimes' that are traceable over their entire life cycles. With this, the completion of products is dispersed to multiple locations and production to stock is only possible for certain components, further increasing the complexity of corporate networks. To counteract this, predictive analytics will be enlisted to anticipate demand, with deliveries effectuated in some instances before the customer has placed the order, or is even fully cognizant of the need, for the part in question.

3.6 Smart & Digital Regions

3.6.1 Sustainable and networked regions

Cities and regions in their present form are to a considerable extent the product of the changed socio-economic circumstances brought about by the Industrial Revolution in the late 18th century. The increased availability of jobs in the cities led to a rural exodus and the formation of the urban centres that are with us to this day. It is therefore more than likely that the profound changes wrought by digitalization and the fourth industrial revolution it brings with it will similarly affect both cities and regions. *Smart regions in the digital age are a conglomeration of urban centres networked with one another and all elements within the region. The watchword of such regions is 'holistic sustainability' – economic, ecological and social – and it is by this yardstick that they are measured.* One of the major paradigm shifts in the consideration of smart cities and regions is their formal delineation. As has already been made clear, functional geography will count for more in the digital age than political boundaries. The political scientist *KHANNA* calls this phenomenon *'connectography'*: the fusion of connectivity and geography that explains the emergence of smart cities. On this analysis, the networking of regions and their importance in terms of the flow of information, goods and finance will be more important in the future than their territorial affiliation. Cities or regions and their local supply chains could become more important than states – and entire counties reduced to mere suburbs of smart cities. [89] However, this also means that the management of these cities will undergo a fundamental change. In order to preserve its status as a smart region of consequence within the global community, it must continually adapt to changing circumstances so as to attract, retain and nurture enterprises and digital talent. It may be necessary, therefore, for smart regions to be managed more like major corporations (as is Singapore, for instance, today) to secure their prosperity – a prosperity buttressed by mobility and logistics.

Mobility furthers *personal freedom*; logistics secures *regional prosperity*. These two factors are therefore essential prerequisites for binding enterprises and digital talent to a region and fostering the growth and development of both. Enterprises in turn ensure the continued development of the region – also and especially of mobility and logistics within it – thereby preserving its overall international relevance. So an upward spiral is generated, massively influenced by the mobility and logistics on offer.

This further underlines the interdependence of the success factors Mobility and Logistics described in this chapter. Connectivity links all components of the infrastructure, as well as all vehicles and their users, with one another. Smart & Digital Regions will also dispose of their own control towers upon which all information converges and from which all central flows within the region are controlled. Based on real-time information regarding infrastructure utilization and pollution levels, as well as other parameters such as total energy consumption, smart regions dynamically determine congestion charge rates, vehicle type quotas and the control of traffic flows in cities. This information can also be used to reduce reaction times and enhance the overall crisis management in the case of major emergencies such as fires or terrorist attacks. It further allows the predictive planning of interventions by the security, fire and ambulance services. Nanophotonics, as mentioned earlier, can be used to monitor health parameters and in case of any ominous departure from the norm, sometimes before subjects are even aware that they are ill, ensure that medical assistance is obtained in time. As well as along conventional arteries – roads, railways, waterways – traffic in the air space above inner city districts must also be regulated. Furthermore, especially in the early days of digitization, traffic will comprise both autonomous and manually driven vehicles, which will call for careful management and the stringent separation of the two modes of transport (e.g. through dedicated lanes).

In addition, the allocation and use of space within various infrastructural elements in smart regions will be significantly more dynamic and flexible. Pop-up logistics, accompanied by pop-up stores, will become established as long term phenomena mainly in the inner cities. Courier services – and Amazon too – are already taking short-term leases on properties, which they then convert for use as warehouses and *micro depots*. [90] In the same way, car parks can become multi-purpose facilities and underground stations transshipment points. Regular retail space can be repurposed during night hours (manned, perhaps, by picking robots or automated in some other way) for the commissioning and preparation of customer orders. The location of bus and tram stops, too, could be dynamically determined, based on demand from users of local public transport networks and continuous analysis of other data.

With the smartification of residential buildings and objects therein, certain transactions, such as the subscription-based delivery of foodstuffs, could be effectuated without a specific order being placed. This increases the need for flexible building use whilst at the same time reducing the demand for retail space, as bricks-and-mortar retail outlets are likely to carry a narrower range of stock. Increasing urbanization will also push up the price of inner-city retail space; this, too, will influence the size of stores.

The increasing tendency for products to be completed in makerspaces or by the customer at home, the proliferation of autonomous vehicles and consequent reduction in the need for car parks (which might then be demolished), as well as new working concepts and their effect on office space, will all add further momentum to the trend towards the dynamic use of space. Smart regions must therefore be just as versatile as regards digital mobility and allow their inhabitants the level of mobility they desire – irrespective of whether or not the latter have the necessary 'mobility equipment'. The reduction in commercial space will mean higher demand for delivery traffic, as storage space and goods buffers will also become smaller; this could lead to an increase in traffic volume that should also be taken into account.

True to their watchword of holistic sustainability, Smart & Digital Regions are designed to be as self-sufficient as possible and to preserve the balance between goods entering and leaving the region. The principle of the recycling economy is therefore sovereign and reflected in virtually all activities within such a region. Built-in sensors in smartified buildings and vehicles will make it possible to determine the exact energy needs of the region. These must then be covered, as far as possible, from alternative energy sources (e.g. solar and wind power) within the region. However, the energy consumed by electric vehicles can also, at least partially, be recycled via the infrastructure with the aid of energy harvesting processes and even passed on simultaneously to other vehicles via inductive charging processes or stored. The waste produced in the region can also be used as a further source of energy and the recycled energy fed into the region's smart grid[24].

As part of the paradigm shift to 'enterprise smart region', administrative processes in urban administrations are to a very great extent digitized and automated. Here, too, the blockchain principle will play a key role. A case in point: Dubai, the middle eastern trade stronghold, is already planning to be the first city in the world to use blockchain technology as the basis for all activities. [92] Moreover, Hamburg's HANSEBLOC consortium, is already working on a solution for the streamlining of transport-related administrative processes using blockchain. [93] In the digital age, this looks set to be the standard. It will also assist administrative bodies and local authorities to become more service oriented by making it possible for inhabitants to submit a great deal more information themselves using self-service facilities. It will also allow the more efficient handling of permit applications, thereby contributing significantly to the retention by the region of both enterprises and digital nomads.

3.6.2 Core theses on smart regions in digital traffic systems

Connectography: The functional importance and networking of regions along with the supply and mobility chains they accommodate will be more important than their formal territorial affiliation.
Proactivity: Land use in smart regions will be considerably more flexible. Multi-storey car parks will become multi-purpose spaces, and underground stations, goods handling centres. Moreover, spaces may be used differently in the daytime from at night (when retail outlets, for example, will be transformed into picking warehouses). A smart region must react proactively and flexibly to such changes.
City-as-a-business: Urban centres will have to be run more like major corporations. The 'citizen experience' and an efficient logistics and mobility system are decisive factors for the regional retention of companies and digital nomads – and for their relevance in the networked global economy. With building-, energy-, traffic- and mobility-management all adding to the workload, as well as a far larger number of interfaces, the administration of smart cities within each smart region will be consigned to the operative control of artificial intelligence – unthinkable without broadband for everyone!

3.7 Hypermodality

3.7.1 Networked locomotion – covering all means of transport

Hypermodality describes an ecosystem of fully integrable and sustainable mobility, logistics and ancillary services that allows end users to assemble their own door-to-door mobility and logistics chains on the basis of their special needs, without requiring them to possess any of the requisite means of transport. *So hypermodality is the perfect fusion of assets, data, products and services, in which the boundaries between private and commercial offers become blurred.*

In the digital age, a multitude of platforms are placed at the disposal of end users upon which the operating mobility curators offer their services for the design of individual logistics and mobility services. The task of these mobility curators is to integrate mobility and logistics fully into the everyday lives of their users. Drawing upon personal data sources such as calendar entries, entertainment services and the interfaces of smartified objects to which the user has granted them access, these curators will assemble the ideal mobility chain for every journey and schedule deliveries to fit in with the daily activities of the user. Users will be able to discover in a few clicks

[24] The term 'smart grid' describes the networking and control of power generators, storers and users of electricity to improve the reliability of the power supply and the efficiency of the network while minimizing emissions. [89]

the quickest way to get to their destination or the earliest opportunity to take possession of a shipment; these could even be suggested to (or organized for) them – perhaps after consulting their calendars.

As mentioned before, these curators will rely here on private and commercial providers of transport capacities. Even though smart city dwellers will be able to dispense altogether with ownership of a conveyance of any kind, a large number of vehicles – albeit considerably fewer than today – will continue to be privately owned. Hypermodality does not imply committing mobility altogether to the 'sharing economy' principle but rather allowing both systems to coexist. This could mean, for example, deciding in view of the current traffic situation that the use of public transport – and hiring out one's own vehicle for the day – represents the most cost-effective and holistically ideal way of getting from A to B. Another day, it could be that use of one's own vehicle is the best solution – but only for part of the journey e.g. the first or the final mile. In other words, no clear and immutable assertion can be made as to which means of transport (alone or in combination) represent the best way of completing the same (everyday) journey.

Owners of vehicles – be they cars, bicycles, pedelecs or whatever – can, on the sharing economy principle, allow other members of the public the use of them. They can do this in various ways: on the one hand, vehicle owners could reduce their exposure to city congestion charges by committing themselves to accept dynamic ride sharing offers. This would mean that those seeking a ride who are on the driver's route and with similar destinations would be automatically allocated seats in the car. Naturally the driver's preference as to the type of passenger, and vice versa, if they had expressed any, would be taken into account. Furthermore, autonomous vehicles could – during their owners' regular working hours, for example, for a consideration reflecting the demand – be entrusted to mobility curators or other mobility service providers who would then make use of them to expand dynamically capacities on routes currently in high demand. We are not necessarily talking here about simply carrying passengers. On the 'belly cargo'[25] principle, the boot of the car could be used to carry goods – as could any spare seats in the passenger compartment. This might be the case, say, if the current user of the vehicle was the intended recipient of the delivery, but the people or goods transported could equally well have quite different destinations, in which case the goods might be dropped off at a central collection station.

The principle of crowd logistics in general will be just one of the many forms in which the fusion of mobility and logistics or hypermodality will manifest itself. As early as 2013, the parcel division of Deutsche Post DHL Group tested a platform on which private individuals could take over parcel delivery to central service points in return for an expense allowance. [94]

Start-ups from Austria such as 'checkrobin' already offer commuters the opportunity to carry parcels on their way to work. In the digital age, such offers are made proactively through mobility curators, who can offer their users rewards as part of a customer loyalty programme in addition to reimbursement of expenses. Crowd logistics offers of this kind are not confined to deliveries in urban centres. Start-ups such as 'CoCarrier' from Berlin also enable holidaymakers and business travellers to become parcel carriers. [95]

In the age of hypermodality, the market for such holistic logistics and mobility offers is competitive, since pure transport is completely commodified and only additional services that go beyond the classic offer of the transport of people and goods make a company profitable. For this reason, customer loyalty will remain of crucial importance to the success of enterprises. As mentioned above (see Chapter 2.2.1), the classic levers of customer loyalty are no longer operative in the digital world.

Loyalty programmes must therefore be designed in such a way that they represent genuine added value for the user. This is not to say that classic inducements, such as fare reductions, will be obsolete; but digital traffic systems will need to cater also to the 'new' requirements of customers, such as the acquisition of emissions quotas or climate neutral travel. Free access to entertainment services and other premium memberships such as Amazon Prime can also be of interest to digital consumers. Access to rewards might be based on the

[25] 'Belly cargo' is other freight stowed in the hold of a passenger aeroplane alongside the passengers' luggage.

‘accumulated miles’ principle but, within the framework of incentives for modal shifts, these could then also be increased as required.

3.7.2 Core theses on hypermodality in digital transport systems

Curators: Mobility and logistics will be fully integrated into the everyday lives of users with the help of enterprises or comprehensive administrative units acting as curators. Mobility tariffs will be calculated and dynamically priced according to the actual distance travelled; in addition, mobility rates will be flat across all providers. Data-driven and asset-driven companies will engage in collaborative competition (revenue & data sharing) in order to meet the needs of users, as the pure transport of people and goods will become even more commodified.

Sharing: In digital transport systems, getting from A to B will in no way be conditional upon possession of the requisite conveyances. Even vehicles that are in private ownership may be made available to the public. Nevertheless, private vehicles will continue to be seen in smart cities and digital regions – even though their number will be drastically reduced. Rather than slavish devotion to the sharing economy principle, there will be a dichotomy between leisure- and job-related mobility: for commuting on weekdays the sharing principle will hold sway, whereas at weekends and other leisure times people will prefer to use their own cars.

Moderation: Hypermodality blurs the boundaries between private and commercial offers. Crowd logistics and crowd mobility could also supply links for door-to-door mobility and logistics chains that are commercially organized for the rest of their length. Alongside commercial offers, non-profit oriented ‘mobility communities’ will exist and offer their services at cost price.

4

HYPERMOTION – MOBILITY AND LOGISTICS IN THE YEAR 2030

4.1 Conclusion: logistics and mobility in the digital age

Logistics and mobility are facing some of the biggest and most disruptive changes with which the sector, and the enterprises operating within it, have had to contend in recent decades. Digitalization and the widespread adoption of new technologies such as autonomous driving and artificial intelligence are steadily lowering the barriers to market entry. In consequence, mobility enterprises not only have to hold their own against known competitors but increasingly, too, against enterprises – some data-, some asset-driven – from other sectors of the economy. They will be increasingly vulnerable to big bang disruptions, which will occur ever more frequently with the shortening of technological lifecycles and sweep away entire market segments in next to no time, displacing many incumbents altogether.

Under the influence of new technologies and other socioeconomic factors, consumer behaviour is also changing. In the digital age, the consumer is accustomed to an immersive purchasing experience and fast delivery times, and expects no less from logistics and mobility services. At the same time, consumers are no longer willing to invest a great deal of time and effort in every decision but expect service providers to appear and assuage their 'paradox of choice' anxieties by picking out the offers that best suit them. Those who fail to do this to the complete satisfaction of the customer will be quickly replaced by others who can, as logistics and mobility in the digital age are still more strongly commodified. This applies not only to end consumers but can also be seen in the B2B area (industrial consumerism). In addition, sustainability and climate neutrality are playing an increasingly important role, which is also reinforced by political efforts to decarbonize.

Logistics and mobility service providers as well as cities and regions must therefore change radically in order to remain relevant to the market and their customers; if not, they will become mere purveyors of transport capacities. This makes the acquisition of new core competences, such as data analytics, as well as the adoption of a more data-driven organizational approach, mandatory. Data within enterprises must be democratized – i.e. made available to everyone – and used for the continuous expansion and enhancement of the company's service portfolio. Enterprises must also be constantly re-evaluating their own core competences and capable of recognizing the opportune moment for a switch (i.e. to a new S-curve), to avoid falling victim to the Nokia-Neckermann-Quelle effect. Enterprises that currently confine their activities to the pure transport of goods or persons will have to be especially vigilant, if they wish to stay abreast of the global advance of digitalization and meet the concomitant heightened expectations placed on providers of logistics and mobility.

Digital disruption will lead in the final analysis to the melding of logistics and mobility into one system, all of whose elements (such as data, people and goods) will be involved in a continuous exchange with one another and find themselves in constant movement. Putting it another way: logistics and mobility will attain a state of hypermotion. The basis for coping with the vastly increased complexity to which this gives rise will be a network structure formed by seven elements described in this white paper as the Hypermotion Grid and summarized in the following paragraphs.

In digital logistics and mobility systems, infrastructure, buildings and vehicles are smartified and capable of providing information in real time about their status, requirements and position. With the aid of M2M communication, autonomous driving on the road will be made possible by traffic control via a central guidance system. The newly tapped data sources create complete transparency across entire traffic systems using uniform data models and indicators and are proactively controlled via a control tower. In the process, the traffic control centres responsible are transformed from decision-supporting into capacity-allocating instances, In addition, traffic data in Smart & Digital Regions is largely democratized in order to allow every stakeholder to profit from the newly won transparency. The logistics and mobility enterprises of the future will use these and their own data to fortify their operative resilience but also to detect new needs of users proactively and adapt their own service portfolios accordingly.

The backbone technology of Logistics & Mobility 4.0 is the blockchain concept, which among other things gives every citizen a secure, validated and digital online identity as the basis for all transactions within the digital ecosystem in which they are involved. It also provides a methodology for the synchronization and uniform representation of all flows of material, information and finance. Logistics capacities such as carrier and warehouse space can be managed in real time, automatically planned and charged on the surge pricing principle. The use of blockchain also contributes to the sustainability of logistics and mobility. On the one hand, the precise level of greenhouse gas and pollutant emissions can be recorded, and residual quotas documented, in a manipulation-proof format. On the other, public nuisances (such as accidents, vibration damage, health hazards and noise pollution) can be internalized in the form of a dynamic city congestion charge informed by the principle that 'the polluter pays'. A further benefit of each user's possessing a digital identity is that allowance can be made, in pursuit of the 'universal design' ideal set to become one of the guiding principles of mobility services and infrastructure, for any physical or intellectual limitations they may have.

Through the enlistment of robots wherever feasible, the production of goods will become commodified, decentralized and conducted to order, which will have the further consequence of bringing production facilities closer once more to the point of use. Private individuals could also contribute to the overall production capacity, for instance by investing in fabrication robots. A detailed calculation of the value generated would then be made for settlement digitally e.g. in crypto currencies.

The altered behaviour of consumers calls for maximum flexibility over the final mile. Deliveries must be slotted in to the everyday life of the customer and delivery processes adapted to his or her habits. The most convenient handover location will be settled upon through negotiation – *inter alia* between autonomous vehicles. Physical products, too, will become steadily more individualized, bringing a shift in the type and volume of freight shipped. Products in the digital age can be fabricated at multiple locations, transforming enterprises increasingly into software suppliers and products into 'spimes' that can be tracked throughout their entire lifecycles.

Cities and regions will be increasingly defined by their networking and importance to the world economy (e.g. in terms of the supply chains they accommodate); national and state frontiers will be of secondary importance. To preserve the importance of the region, cities must accordingly be led more like corporations, in the quest to bind enterprises and digital nomads to the region. In addition to the digitalization and automation of administrative processes, mobility and logistics are key factors in the creation of an immersive 'citizen experience'. Mobility furthers personal freedom; logistics secures regional prosperity. Without either, it would be impossible for regions to hold on to their enterprises and digital talent. Enterprises in turn ensure the continuous development of the region, thereby preserving the international relevance of the region as a whole. Smart cities will make far more flexible use of the available space. Multi-storey car parks could become multi-function areas and metro stations goods handling centres.

The aggregate of logistics and mobility services in digital transport systems is a highly fragmented ecosystem made up of service providers and private individuals, in which the dividing line between private and commercial offers is often blurred. With the help of mobility curators and their platforms, users can assemble individual mobility and logistics chains reaching from door to door, without having to possess any 'mobility equipment' of their own. Nonetheless an admittedly smaller, but nonetheless considerable, number of vehicles will remain in private ownership. In keeping with the ethos of the sharing economy, these might on occasion be entrusted to mobility enterprises, which could then deploy them to make dynamic capacity adjustments. The principles of crowd logistics and crowd mobility will therefore be among the axioms of Logistics & Mobility 4.0, and find expression in otherwise commercially organized door-to-door mobility chains, the corollary being that traditional taxis will be absent altogether from the streets and highways of smart cities and digital regions.

4.2 Outlook: what else will be different?

What form the future of logistics and mobility will take remains fascinating and offers many opportunities for participation. What is certain, however, is that the digital disruption we are seeing now will lose nothing of its momentum and the transformation will continue uninterrupted. It is still open to enterprises within the sector to play an active part in shaping the future of locomotion and change significantly their own roles or positions within the industry. The core competences of the future must not, and will not, correspond to those currently occupied by logistics and mobility enterprises. National and local governments must also take on new tasks to add impetus to the transformation of the sector.

Digitalization also makes further development of the metrology of transport efficiency and the performance of logistics and mobility imperative. Current indicators and bases for measurement are derived from a more asset-based perspective and their ability to reflect the changes brought about by digitalization is somewhat limited. A case in point is the Logistics Performance Index (LPI), published biennially by the *WORLD BANK*. This does admit the possibility of paperless documentation processes, customs declarations and shipment tracking [96] but other competences associated with digitalization have so far been left out of consideration. Competences in the fields of data analytics and early warning systems, for example, are disregarded in assessing the quality of logistics services. The same goes for access to real-time data and proactive control of traffic flow, to which no consideration is given in the evaluation of infrastructure.

Furthermore the measurement of traffic performance (e.g. in the form of the modal split) needs to adjust to changes brought about by digital disruption. The modal split affords a typically asset-based view of traffic volumes within a city or region; this needs to be converted into a service-based one. Furthermore, new hybrid forms, such as pedelecs, give rise to a need for new categories to be included in the split. Retrospective assessments are of no interest to the user anyway. What is increasingly determinative of the choice of personal travel chain and preferred ordering method is credible information on the user's smartphone i.e. the *digital mobility split.*

5

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TABLE OF ILLUSTRATIONS

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LIST OF ABBREVIATIONS

a.k.a.	also known as
B2B	business-to-business
B2C	business-to-consumer
CEM	customer experience management
CO_2	carbon dioxide
CRM	customer relationship management
DIW	*Deutsches Institut für Wirtschaftsforschung* (the German Institute for Economic Research)
DUH	*Deutsche Umwelthilfe* (Environmental Action Germany)
e.g.	*exempli gratia* (for example)
EB	exabytes
EU	European Union
Fig.	figure
GB	gigabytes
i.e.	*id est* (that is to say)
IoT	Internet of things
ITS	intelligent transport systems
LOHAS	lifestyle of health and sustainability
LPTN	local public transport network
M2M	machine-to-machine
MIT	Massachusetts Institute of Technology
N/A	not applicable
NGO	non-governmental organization
NO_2	nitrogen dioxide
SC	supply chain
SMEs	small and medium-sized enterprises
Tab.	table
UK	United Kingdom
UN	United Nations
ZB	zettabytes
ZEW	*Zentrum für Europäische Wirtschaftsforschung* (Centre for European Economic Research)

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Synchronized & Urban Logistics

›› How should a synchronous and customer-driven value creation chain be designed?
›› Which concepts enable cost-efficient and flexible last-mile delivery?
›› How can products be transformed into product service systems that are traceable over their entire life cycle?

Connectivity

›› How can status data for buildings, infrastructure and vehicles be created and transferred?
›› How can participants in transport and logistics systems communicate more effectively with each other?
›› What innovations exist for networking logistics and mobility?

Monitoring & Transparency

›› How can complete transparency be created across all logistics and mobility processes?
›› How can logistics and mobility processes be viewed in an integrated manner and proactively managed?
›› How can data be made available centrally for the benefit of all process participants?

Sustainability

- How can emissions in logistics and mobility processes be better measured and avoided?
- What concepts exist to promote the social sustainability of logistics and mobility?
- How can external costs be better anticipated?

Data Analytics & Security

- How can logistics and mobility processes be continuously optimised through data analysis?
- How can the needs of the end customer in logistics and mobility processes be better understood and anticipated through data analysis?
- How can financial transactions in logistics and mobility systems be made secure?

Smart & Digital Regions

- How must cities and regions be reorganised in the context of the digitisation of logistics and mobility?
- How can the use of space in smart regions and cities be made more flexible?
- How can the "citizen experience" be improved through digital transformation?

Hypermodality

- How can personalised logistics and mobility chains be created that are individually adapted to the end customer?
- How are logistics and mobility processes changing as a result of digitalisation and decarbonisation, and what are the resulting opportunities for all participants?
- How must logistics and mobility systems be redesigned through digitalisation as a result of intermodal systems?

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