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Macro-analysis of the evolution of motorised mobility and relationships with the development of motionless communication systems

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Abstract: This study deals with the relationships between two different types of human communication: *mobility* – i.e. communication with movement – and *motionless* communication, sometimes also called virtual mobility. The aim of the study has been to carry out an analysis of *modern motorised mobility* around the world, considering the evolution of ITS. The final goal has been to provide an added value to the numerous publications already available on daily mobility, by selecting common elements and pointing out the role of being connected in future transport systems, in this way contributing to the pursuit of 'interconnected transport systems': the Latin root of *intelligent* has two meanings, one of which is *interconnect* (*inter-lego*). An analysis on the long-term evolution of the main transport mode, that is, by car, has pointed out that an economic cycle has been completed in most motorised countries: this also complies with historical theories on the subject. However, new motionless communication systems have appeared on the market over the last decade, and they have become actual competitors to motorised mobility or, hopefully, collaborators. Therefore, a new cycle of cars would be possible, under certain conditions – one of which includes being connected – a requirement that this study wishes to outline with the help of some numerical analyses.

1 Movement and motionless communication: the role of speed

It is well known that communication with movement can be of two types:

(i) *motorised,* which involves the use of vehicles equipped with an internal combustion engine, an electric motor or both, such as cars, buses, motorcycles, trams, metros and trains;
(ii) *non-motorised*, through the use of bicycles or simply walking, where the person himself, muscle-powered, generates movement.

Motionless communication includes a range of personal and social interactions that can take advantage of the recent highly developed technologies, based on networks, and which are nowadays globally interconnected, that is, the Internet, which offers public accessibility. Motionless wireless communication is currently the main means of mass communication, as the number of daily bi-directional connections (teleconferences, e-mails, personal mobile communications and the like) testifies; none of these systems existed before roughly a quarter of a century ago (before the late 1980 s) or, as outlined hereafter, during the last decade [1].

For human beings, it has always been necessary *to move*; over the centuries, this activity has evolved at the same pace as Man himself. The *time* that human beings have devoted to travelling, according to some studies [2–5], has been approximately constant over time [3, 4, 6, 7]. In the 1970 s, the so-called 'travel time budget', that is, the average amount of time that people use daily to move, seemed established; this budget, according to some well-known studies in literature, is about an *hour per day*.

Many studies have also recently become available concerning daily mobility and its compliancy with user preferences for electric vehicles or for the electric traction of hybrid vehicles in urban contexts, which can also make use of well-developed internal combustion engines where electric charging is unavailable and the masses or distances to cover are relevant [8–14]. Recent measurements have shown similar travel time values, even in radically different countries [15–18]. It is amazing how, in this broad and macro generalisation, such a close link can be found with the past. It has been estimated that even 5,000 years ago, the travel time budget was an hour a day, although the average speed was lower [5, 10]. Many things have changed since then, but despite this, people seem to continue to devote approximately the same amount of time to mobility, although in a *higher travel space*. A question therefore arises naturally: how is it possible to explain and interpret this phenomenon and can it be conserved in the future?

Unsurprisingly, the means used to move have evolved; historical needs and urban development led man to first use and exploit animals and then motorised vehicles, in order to significantly increase the *speed of movement*. Since this speed has increased, it has also been necessary for the *space path* to increase proportionally with the speed in order to maintain a constant average 'travel time budget', which, for the time being, has been considered one hour per day. This concept can be simplified by considering that people generally travel many more kilometres than in the past at higher speeds, but the same amount of time per day is dedicated to moving, for many and varied reasons. As a relevant example, rail transport, which has invested a great deal of funds in raising speeds since the 1970 s, both by increasing speed itself on existing lines through the introduction of tilting trans and by constructing *ad hoc* lines for high speed trains, has increased traffic and enlarged its basin of influence to 600–800 kms [19], as larger distances are covered at higher speeds, in Japan, France, Germany, Italy, Spain and in other countries. Fig. 1 shows the maximum speed records – which, of course, do not represent the operational speed along railways – that have been reached by trains since the beginning of their history.

Nowadays, further increases in rail *speeds* frequently seem to be limited by *territories* – i.e. the actual distances between cities that can take advantage of the increase in speed – and by the need to *select* large cities when setting up new network branches, thus sometimes betraying or bypassing smaller or medium-sized urban

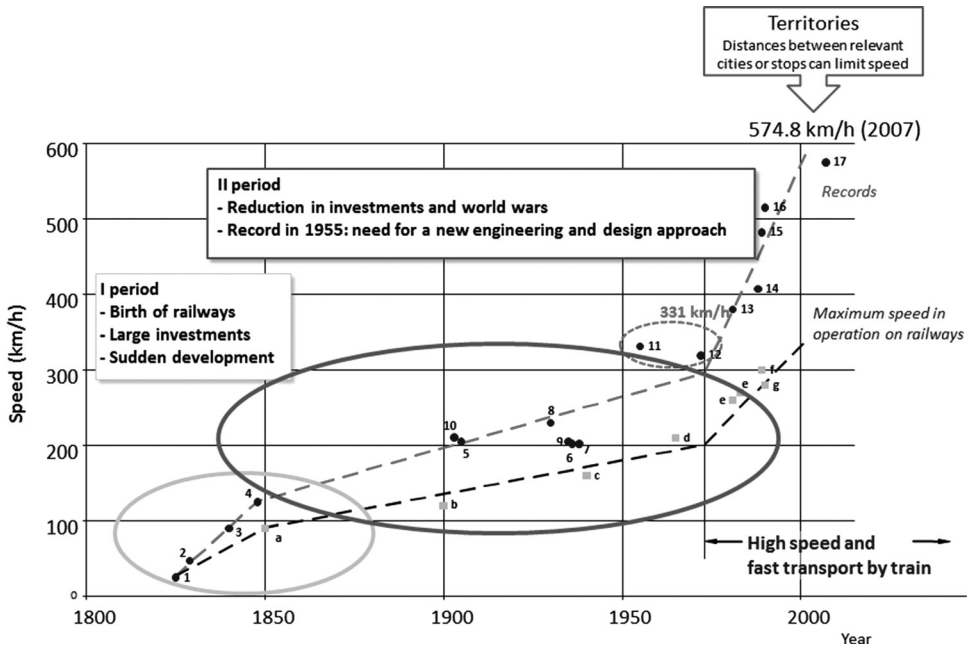

Fig. 1 *Records and maximum train speeds (elaborated on the basis of [20])*

centres. Technical constrains also sometimes play a role, for example, the wear of rails, energy absorption or safety reasons related to train dynamics. As far as cars are concerned, a limit on the increase of speed that the diffusion of highways and motorways led to, mainly during the 1960–1990 s of the last century, can be associated nowadays with goals of higher safety and, in some cases, with the spread of ITS applications addressed to identifying infringements of speed limits, even in the absence of police forces.

In recent decades, something has been changing: Zahavi's theory [5] seemed to work for the past, from prehistoric times until today or, rather, till yesterday. An unexpected phenomenon, that is, a *change in the growth of motorised mobility,* and sometimes a decrease in *physical trips,* can now be witnessed. In addition to a number of known causes, such as economic, sociological and psychological issues, it is impossible not to note a relatively recent occurrence: the development of motionless communication systems, such as the Internet [21], mobile communication via smart phones, teleconferences, and the like, and therefore an increase in the so-called *virtual-movement*. The differences between virtual and motorised mobility are clear and consistent. These two phenomena coexist and, on occasion, *cooperate,* but numerical analyses have shown how the development of motionless communication has possibly influenced the partial decline or conservation of motorised travelling. It could be useful to consider how far the use of virtual movement can undermine and eventually overcome physical movement.

2 Change in the growth of motorised mobility

An attempt has first been made to justify the basic assumption of the above considerations: the change in the growth of motorised mobility. Over the last decade, and in the most diffused transport mode, the growth in the number of cars and in their use has slowed down, stopped or even become negative [22] in several developed countries (Fig. 2). This change cannot be attributed to adverse economic conditions alone, but might instead be due to a physiological and behavioural *adaptation of modern societies*. Car ownership saturation, here intended as the ratio of people who are able to drive to the total adult population, socio-demographic factors, including population ageing and changing patterns of education, work, and household composition, all play roles. The rise in urbanisation, as well as the less car-oriented and more environmentally reliant policies of some cities could also be responsible for the reduction in the growth of car use, perhaps together with changing attitudes towards mobility. Some individuals choose to use cars less; others are forced to. Undoubtedly, another important factor is the aforementioned growth and development of *motionless communication*, which allows people to get in touch easily, quickly and at a low cost. An index of passenger-km volumes by cars for a group of high-income economies, from 1990 until 2011, is shown in Fig. 2, considering some data from the International Transport Forum [23]. A slowdown in growth is clear in Germany. It began sooner in France, as can be seen from the fact that car use has almost remained unchanged since 2002. In Japan, the decline started in 1999, while the growth factor in the UK has been negative since 2007, but had already started to slow down in 2003.

One aspect that should be considered is the difference between countries in the developing world, where the motorised mobility market is currently under full development, as is the growth in technologically advanced motionless communication systems, and developed countries, where a stagnation, sometimes even a decline, of motorised mobility can be observed.

The International Energy Agency analyses, explains and makes forecasts on worldwide energy policies, using year-per-year data and statistics. In 2008, two important turning points were observed [24]: for the first time, the estimated CO_2 emissions from non-Annex I countries surpassed those of Annex I countries, and the CO_2 emission levels of Annex I countries fell below the 1990 levels [By developing countries, we mean non-Annex I parties to the UNFCCC (United Nations Framework Convention on Climate Change). The Annex I parties to the 1992 UNFCCC are: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, the European Economic Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lichtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States.]. Global CO_2 emissions increased by 0.4 Gt-CO_2 between 2007 and 2008, which means a growth rate of 1.5% [24, 25]. However, the trends varied to a great extent: emissions in Annex I countries decreased by more than 2%, whereas emissions in non-Annex I countries increased by almost 6% [24]. Industrially developed countries have been considered in the present paper.

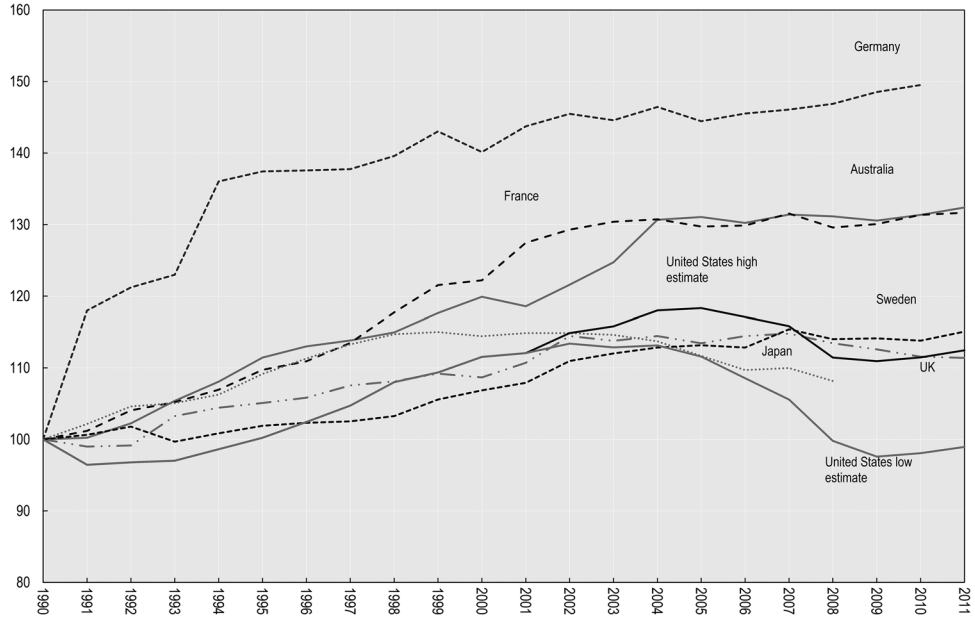

Fig. 2 *Passenger-km by private cars (year 1990 = 100) [23]*

A study [26] shows that the habits of US population have changed since they have begun to drive less (Fig. 3), as pointed out in [27]. For about 10 years now, a new trend has been emerging in the transport sector: the preservation of motorised mobility in most industrialised countries. From 2004 until 2011, the miles/year driven by the US people showed a 6% decrease. The aforementioned publication lists a number of reasons that could explain the phenomenon of the decline in the mobility growth, such as the *rising cost of fuel, when occurring*, *new laws regarding driving licenses*, *the economic crisis*, *environmental impacts*, *the technological development* of motionless communication and *socio-psychological reasons*. These reasons can be generalised to other developed countries. The report deals with young people aged between 16 and 35 years. The part that is of interest for the purposes of this paper is the development of motionless communication technology. Improvements and expanded accessibility to communication technology have led to a reduction in the number of trips taken by car. Social networking technology has become a substitute for some types of car trips [28, 29].

Young people today value or prefer constant contact (interconnectivity) with their peers through websites and mobile phone applications, social networking platforms (such as Facebook and Twitter), instant messaging software, cell phones and video chatting platforms (e.g. Skype). Some young people, who spend time interacting with friends through communication technology, have less time and desire to drive anywhere to see anyone. Communicating through these new technologies has decreased the necessity for young people to use cars. A recent survey [30] has found that many young people have substituted driving with social networking. According to the survey, 54% of the young people interviewed agreed completely or to some degree with the statement that '*I sometimes choose to spend time with friends online instead of driving to see them*' (Fig. 4).

3 Historical path, growth and development of motionless communications

Virtual mobility makes Europe and the whole world accessible to anyone who does not have the ability or economic possibility of physically moving, although places and people are 'reachable' in a *reduced way* compared to a personal presence: Information and Communication Technology (ICT) can be seen as the means of 'getting to' activities that would previously have required transport, or would have been impossible to do. A wider community can take advantage of all those forms of virtual mobility that technology has made available. The combined and increasingly widespread use of the latest generation of tablets, laptops and mobile phones allows one, among other things, to work remotely, to buy from shops without having to go there in person, to book journeys while sitting on the couch, to deal with personal relationships through e-mails and video calls, to manage a bank account through home-banking services and, in some cases, to interact with public administrations.

Table 1 shows when technological-mobile innovations were first introduced, while Table 2 displays the worldwide use (penetration rates) of these breakthroughs in the year 2009 [31].

The key applications that are making an impact on travel behaviour and the way things are transported are: *e-business* and *e-commerce* (business to business and business to consumer, online transactions and service/product delivery); *e-work* (teleworking, telecommuting – all forms of remote work using ICT); *e-services* (e-government services, e-learning, telemedicine, etc.) and *social networking*. All of these, in principle, imply that physical travelling has to some degree been replaced by online activities involving the new ICT. However, the impacts of such changes are not so straightforward. Broadly speaking, the impacts that some researchers and policy-makers are looking at are: *replacing travelling*; *working alongside physical travel*; *generating new journeys* as well as *redistributing travel and goods transport* (in terms of time, location and who does it or what is transported). The two internet applications that have had most effect on motorised mobility are analysed hereafter.

E-business and e-commerce – The Internet allows virtually all the phases of physical shopping to be performed, in some cases also trying on and touching, that is, searching for products, searching for sellers, viewing products and reading information on them, comparing prices, and eventually purchasing goods. Therefore, shopping has geographically become extended to a potentially global market. In the EU, in general, only 23% of the total population used e-business and e-commerce in 2005–2006, and this percentage was therefore equal to the share of the population that purchased through the more traditional postal service, but which still permitted shopping at a distance. Four years later, in 2010, this rate had increased to 33%, with peaks up to 53% in UK [31].

On the other hand, it is necessary to consider the fact that goods still have to be moved and delivered to online shoppers' houses, even more than once in case the service includes free trials.

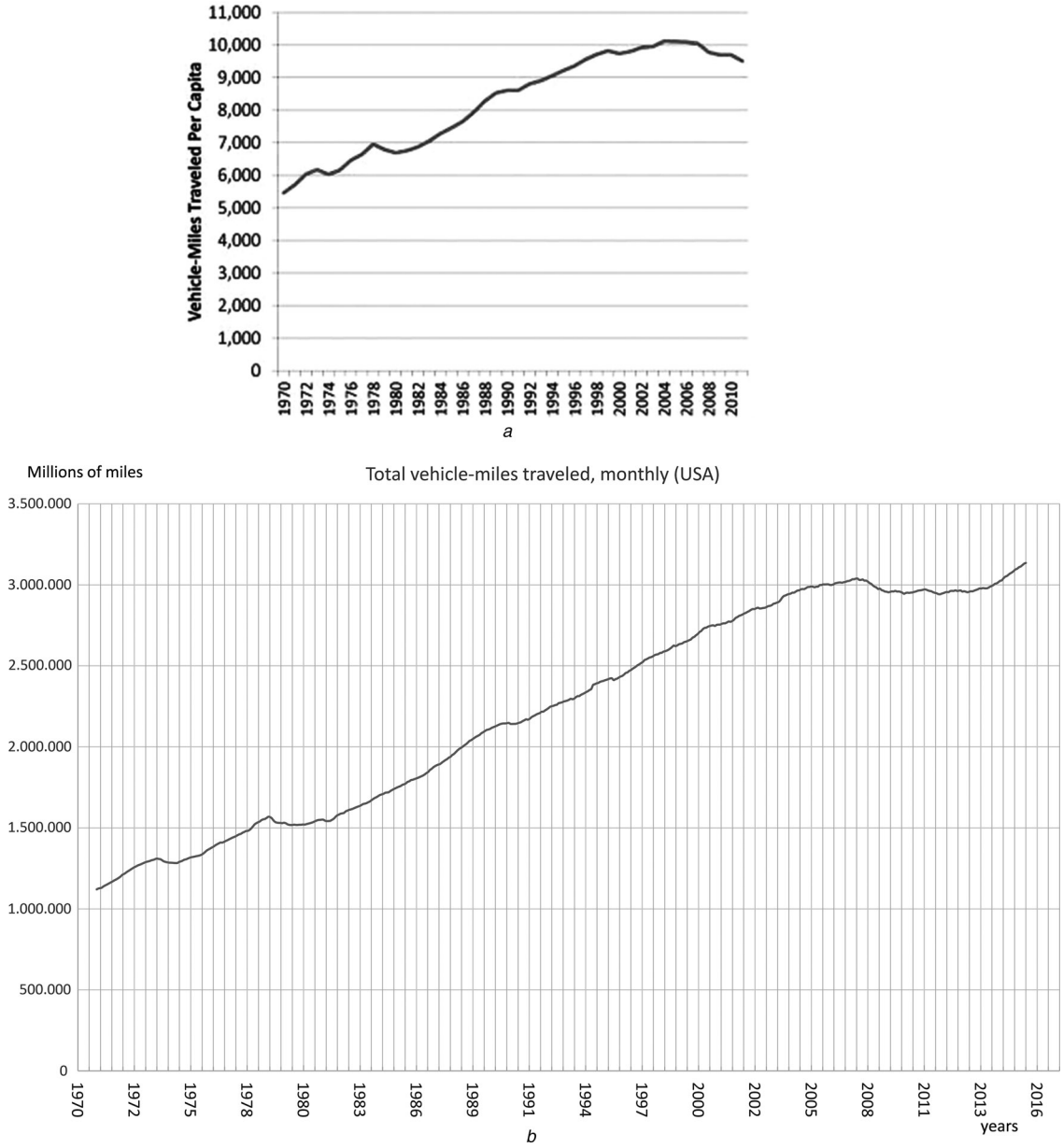

Fig. 3 *Vehicle-miles travelled per capita with a peak in 2004 [27] and an elaboration of US Federal Reserve Economic Data, Economic Research Division, 2016*

Therefore, it can be seen that there might or will be a decline in the number of people that move, but not in the movement of goods in general, that in some cases are bought (online) and delivered to houses. However, it is rather ironic how one of the most important slices of the online market is that of the purchase of airline tickets, hotel reservations and similar. Basically, about one third of online shopping helps to increase motorised mobility via touristic trips and the like, as can be seen for example from relative shares of the e-commerce market [32].

E-work: market trend for videoconferencing – The video conferencing market undermines physical mobility related to the world of work, for the following possible reason: evolving technologies and innovative application scenarios offer videoconferencing renewed vitality. Four trends have driven the advance in videoconferencing technologies: *lifelike experiences* (delivering these experiences depends largely on audio/video restoration capabilities and the utilisation of intelligent technologies that are suitable for human societies; telecommunication technologies allow users to feel that a conference is actually being held 'face to face'); *widespread use* (optical fibres are replacing copper ones in network construction; the accelerating spread of low-cost and high-speed data services); *industry specific applications* (industries are all undergoing information technology transformations; with the maturity of high-definition technologies, telepresence systems have begun to be deployed extensively in different industries and are now playing a vital role in this transformation) and *environmental friendly technology*: according to the Global e-Sustainability Initiative, proposals in the ICT industry might be able to reduce emissions by nearly 7.8 billion metric tons of carbon dioxide equivalents by 2020. The 4G era is taking shape and 5G is embryonic as network technologies are upgraded and triple play services become more prevalent. A migration from standard definition technologies to high-definition technologies is under way; all these developments create a potential for enhanced videoconferencing technologies.

Recent developments have underlined the worldwide intention of achieving greater access to networks and of reaching the maximum national coverage. In order to measure the growth in access to the Internet and the deployment of broadband infrastructures, an international institute [23, 33, 34] has collected comparative data to report on several indicators, for both fixed and wireless access

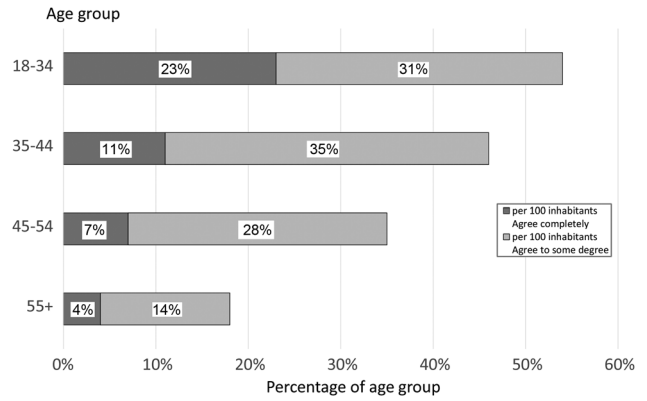

Fig. 4 *Young people substitute driving with social networking platforms [30]*

Table 1 Mass introduction of mobile innovations [elaborated on the basis of 31]

Innovation	First year of mass production in some cases, indicative
basic devices	
laptop PC	1975
mobile phone	1983
l(GSM standard by ETSI in Europe)	(1993)
information systems	
internet	1994
SMS	1999
transmission systems	
Wi-Fi	1991
3G	2001
advanced devices	
smartphone	1993
netbook	2007
tablet	2010

to the Internet. A measure commonly used for broadband penetration level is the number of broadband subscriptions, which provides an indication of the number of connections supplied to users by network operators. Subscription data have the advantage of being available in a timely manner, and they provide an accurate picture of the number of broadband lines in use in different countries. Fig. 5 (left-hand side) plots the development of fixed broadband subscriptions in the OECD area. It can be seen that by the end of the second quarter of 2010, the number of fixed broadband subscriptions had grown by 17.4%, reaching on average 24.4 subscriptions per 100 inhabitants. This growth rate is significant as the subscription level in 2008 was relatively high and markets were considered to be close to maturity at that time.

The progress in broadband deployment has been underlined by an important increase in quality, especially in terms of the greater capacity of lines, which has also involved an increase in the fibre deployment rate. Since the end of 2008, fibre-to-the-home and fibre-to-the building subscriptions have increased by 33.1%, from 2.13 subscriptions per 100 inhabitants to 2.81 subscriptions per 100 inhabitants (Fig. 5).

Fig. 6 shows wireless broadband penetration in June 2010, where it can be seen that subscription rates were very high for Korea, Sweden, Japan and Norway, with over 70 subscriptions per 100 inhabitants. The dedicated mobile data subscriptions in Korea are an important part of the overall data subscriptions, and it is expected that data subscriptions will increase significantly in the OECD area. The increasing number of subscriptions is related to the increased availability of high-speed broadband, whether fixed or wireless, as well as to the significant changes that have occurred in the types and availability of terminals that support mobile broadband.

4 Correlations and future scenarios

Technology affects the lives of people in various ways. As far as the field of transport is concerned, it has been recognised that cars have revolutionised travelling, and this process started approximately one

Table 2 Penetration rates of communication technologies according to world regions – year 2009 – (in population %) [elaborated on the basis of [31]]

Region/medium	Africa	Asia and Pacific	Arab states	The Americas	CIS	Europe	World
fixed-line telephone	1.6	14.0	9.4	28.1	26.6	40.1	17.1
mobile phone	37.5	56.0	72.1	90.4	118.9	127.8	76.1
internet	8.8	18.4	19.3	35.7	48.3	62.9	30.0
fixed broadband	0.1	1.7	4.6	6.5	14.3	22.4	8.0
mobile broadband	2.2	5.4	5.7	16.1	19.1	33.0	13.4

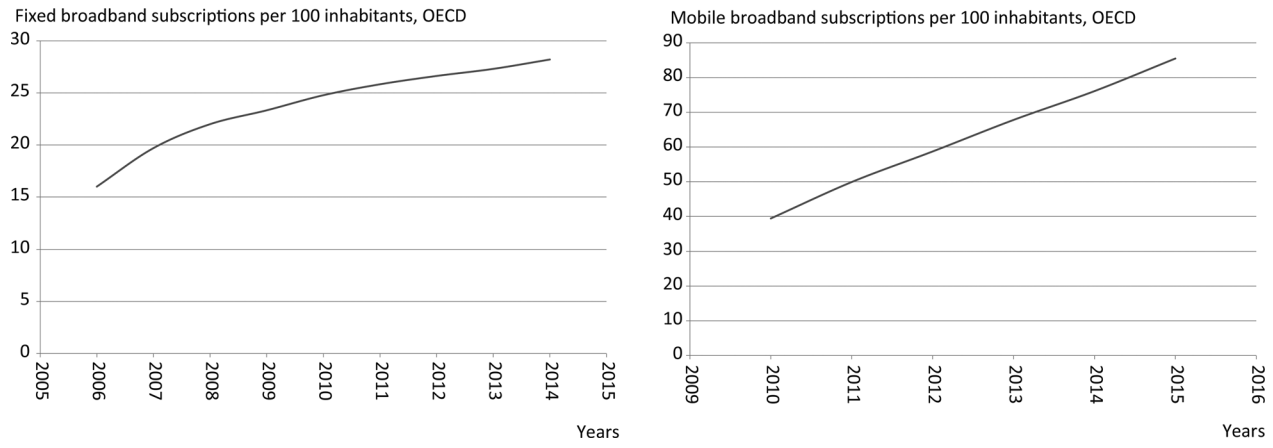

Fig. 5 *Fixed (left-hand side) and wireless mobile broadband (right-hand side) subscriptions per 100 inhabitants in the OECD (y axis) in recent years (x axis) [34, updated with OECD, doi: 10.1787/902e48ee-en and OECD (2016), doi: 10.1787/1277ddc6-en (accessed on 12 April 2016)]*

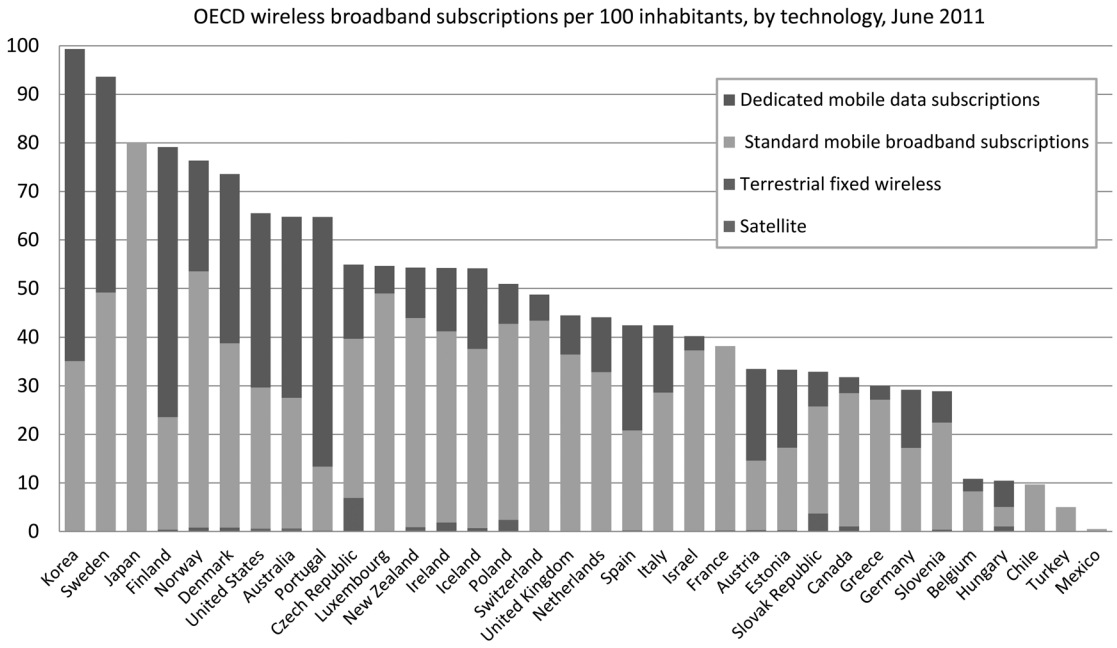

Fig. 6 *OECD wireless broadband subscriptions per 100 inhabitants, by technology – June 2011 [10]*

century ago. The *speed* of *road vehicles* and, more recently, of *trains* (HST) has modified travelling over the last few decades: three decades ago, computers began to modernise almost every aspect of modern human activities. Roughly 10 years ago, it was the Internet and, in a broader sense, *bidirectional* communication that transformed the two previously mentioned aspects, as well as the social behaviour of human beings.

An almost century old well-known physical concept, related to technology, can be used to obtain a better understanding of the global changes that have invested our past and that will project us into the future: the *Kondratiev cycles* [35].

The Russian professor observed [35] that the development of market economies was characterised by approximately 50–55 year long waves or cycles. In the 1930s, the Austrian researcher Schumpeter showed that these waves correspond to *innovation cycles*; they are characterised by new technologies. Each cycle consists of four stages: prosperity, recession, depression and improvement. Man is currently living in a fifth innovation cycle that is giving rise to an information economy, which uses the energy of the human brain for research and development in fields such as industrial services (i.e. software), mechatronics, biotechnology and robotics. As far as these new assets are concerned, the United States has a formidable rival in the form of Japan. The recession of the seventies can be seen as the combined result of rising crude oil prices and the transition from the fourth to the fifth cycle. The closure of several factories in developed countries could have been due in part to competition from NIC [Newly Industrialising Countries are those countries that, since the 1970s, have become relevant production centres and which mainly belong to the Latin America area – Mexico and Brazil – and the South-East Asian area – Hong Kong, Taiwan, Singapore and South Korea] and some producers in the Third World, but this was accompanied by a continuous development of services, so much so that the term 'post-industrial society' was introduced. From an elaboration of the Kondratiev wave graph (Fig. 7), the importance of *motionless communication* in the present historical period emerges, this being the great technological revolution of our times in this context. Given the importance that this innovative form of communication has on society, it is logical to presume that it also has an influence on the present concept of motorised mobility, which, in the past, represented the great revolution of a bygone era. Nevertheless, it is the responsibility and prerogative of the

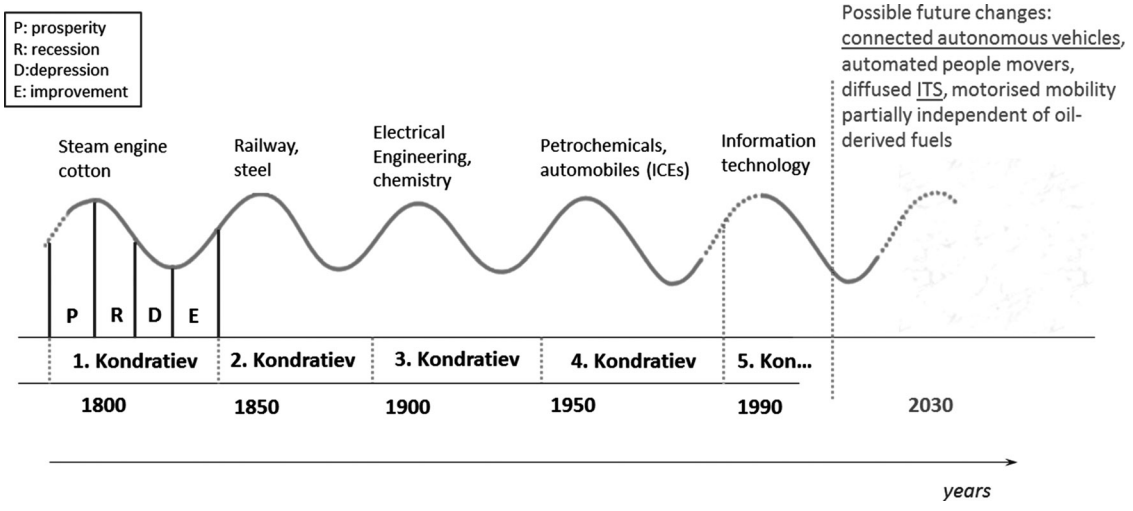

Fig. 7 *Simplified Kondratiev Wave Pattern and its extension to future years in relation to transport systems [source: elaborated on the basis of Kondratiev's waves]*

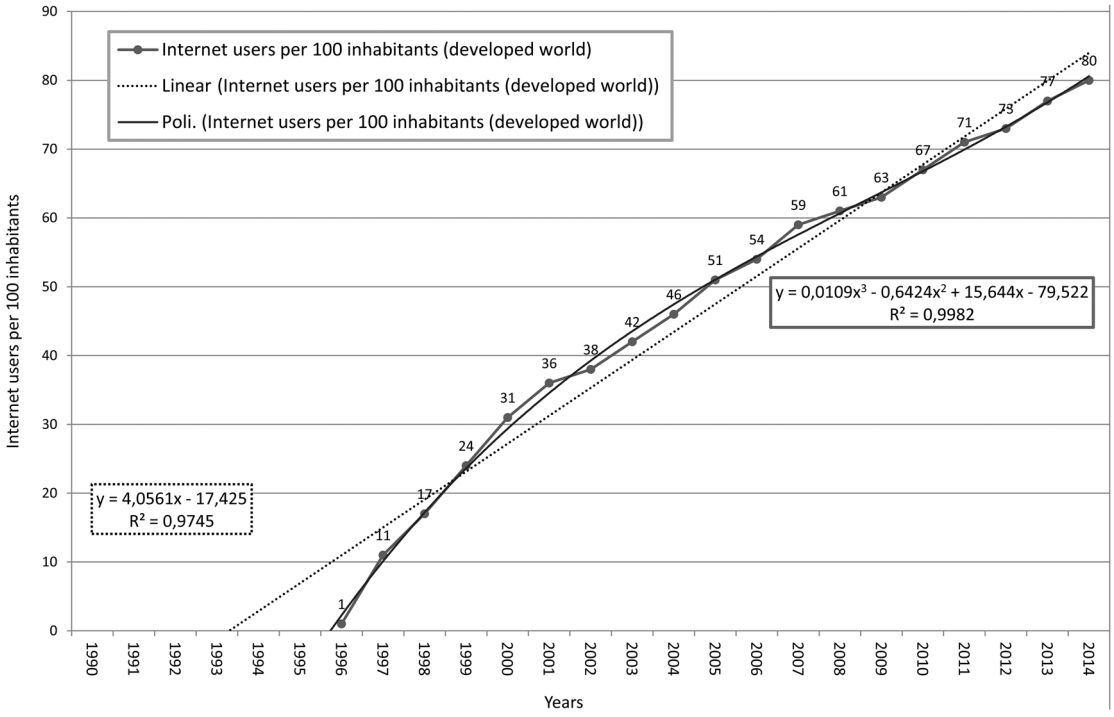

Fig. 8 *Internet users per 100 inhabitants [data source: elaborated on the basis of the International Telecommunications Union]*

transport engineering field to *reinvent motorised mobility in order to guarantee a new cycle*, as can be seen in Fig. 7.

To mathematically analyse what has emerged so far, the diagrams in Figs. 8 and 9, which show the trends of development from 1990 to 2014, can be observed. The global growth in the number of internet users is reported in Fig. 8: only the developed world has here been considered. In this case, the trend line that best describes the situation is a simple third-order polynomial equation.

The function that best describes the trend can be identified as

$$f = 0.0109 \times^3 - 0.6424 \times^2 + 15.644x - 79.522$$

with $R^2 = 0.9982$.

To propose a trend function, a point interpolation can be made; in this way, it is possible to see the development that could be expected over the next few years, that is, a further pronounced growth.

From Fig. 9, it is instead possible to observe the trend of passenger·km by private cars in two different countries: Germany and France. These two countries have been chosen as a representative sample of a part of the developed world. The trend functions that best define the situation are logarithmic.

Performing the calculation of the first and second derivatives of the functions, in order to study the growth and concavity, it is possible to note that the second derivatives are both negative; in fact, the functions have downward concavity. Furthermore, as a logarithmic function, it can be noted that growth tends to stabilise.

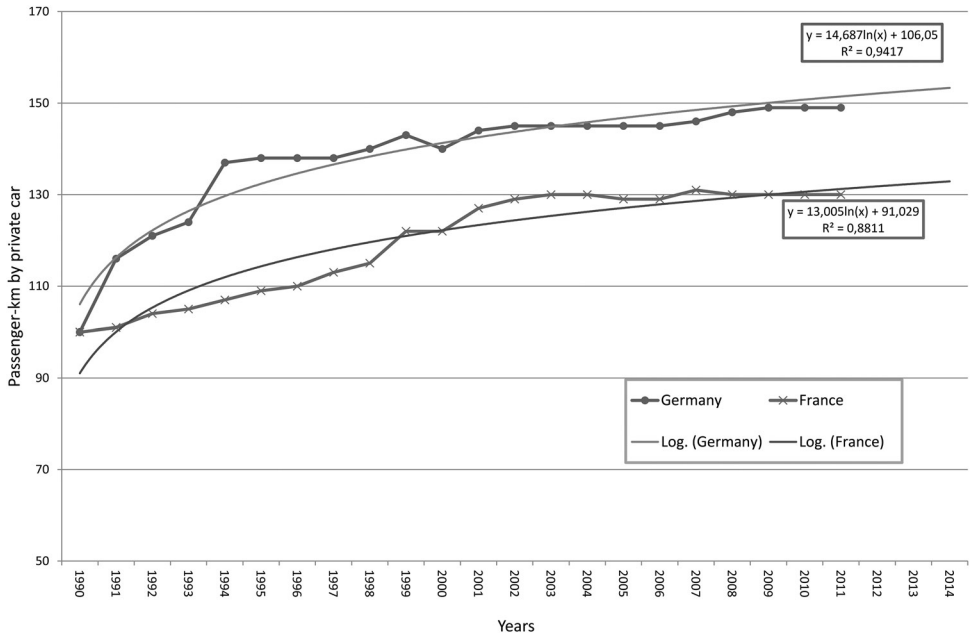

Fig. 9 *Passenger-km by private cars [Year 1990 = 100] [data source: 23, 33]*

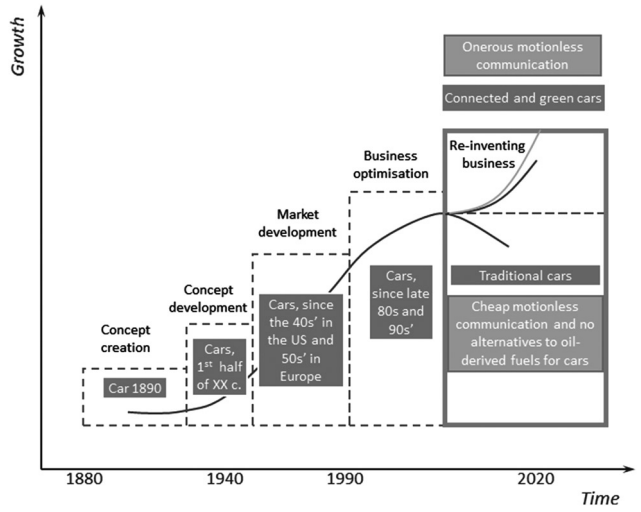

Fig. 10 *Typical product – business cycle applied to automobiles in most industrialised countries where diffused motorisation has already taken place*

Before the 1990s, the growth in the use of motorised mobility was of the same type as that shown in the graph of Fig. 10, so as this seems to be confirmed by the vehicles in the market from a sample country, as reported in Fig. 11.

However, a change in the growth of this type of mobility can be seen, starting from the introduction of the Internet, in favour of motionless communication development. *Private motorised mobility needs to be renewed*, otherwise the current trends of stagnation could continue and could even become worse (Fig. 10, lower right-hand side). Assumptions of static, exogenous consumer preferences can strongly bias the market potential results for new, pro-environmental technologies [36], in particular with reference to a new concept of connected and green automobiles, with assisted driving. Assisted driving requires ICT, puts the bases for automated driving, and inevitably relies on interconnected vehicles. It should be recalled that *interconnected* has the original meaning of *intelligent*, as it comes from the Latin *inter-lego*, which means 'I link together' or 'I link with or through' [Another meaning of *inter-lego* is 'I read through', which means being able to read between the lines, in other words being *intelligent*]. Therefore, all this implies a very wide and long-lasting path for ITS, in this context intended as *interconnected* and also intelligent *transport systems,* in which motionless communication is permitted in vehicles so as to continue to allow travellers to have remote connections, even when moving to meet people, for work, visiting places in presence, practising sport or just for leisure. A stimulating yet also necessary connection to prevent transport from being partially outranked by motionless ICT uses: *ITS can allow a common future of collaboration between transport and communications*.

Some authors [37] have found insufficient evidence to establish a link between the effects of a contribution of Internet access and the changing of different types of physical activities into virtual activities. Considering the case of the Netherlands, which is similar to many other countries, a significant change in the use of cars by young adults has been observed, which has decreased since 1995, both in terms of the number of trips and the number of kilometres travelled. However, no clear relationship between changes in driver's licenses and car ownership have been found.

However, in some cases, this reinvention of transport systems in an ITS context has already begun: there are already road vehicles which have computerised equipment on-board and continuous vehicle monitoring, with the aim of achieving automated driving. This equipment necessarily includes a *black box* – in Europe, a consequence of the compulsory introduction of e-calls, since 2018 - and integration with motionless communication, which is partially or wholly independent of oil-derived fuels.

In this context, one of the main research contributions to the introduction of new electric vehicles based on batteries is derived from some well-known ICT industries, such as Google and Apple: these vehicles include self-driving functions as one of the main innovations. Although many relevant car makers are producing successful plug-in and electric vehicle models and industry collaborations could represent an interesting opportunity, in this product development phase, the two sectors seem to have a competitive approach. This could be related to different customer and market viewpoints as well as to a more flexible production approach – such as that of micro-factories – that the ICT actors would like to introduce to this new challenging mobility product.

These issues lead to another relevant point, which has been left for further research in the transport and ITS context, as it is beyond the scope of this paper: the interconnection of vehicles introduces a new concept, which could not have been pursued in the past. So far, vehicles have been used because their *physical positions* are known at a given moment; this could be a car parked close to one's own house, which can be used since it is there; it could be a

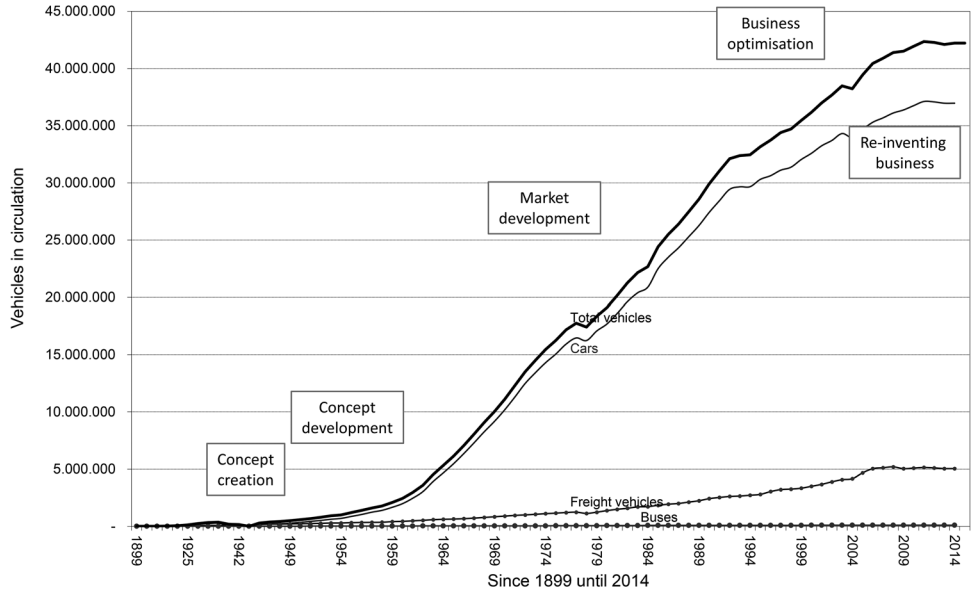

Fig. 11 *Vehicles in circulation in Italy in the last and present centuries (a similar trend as in Fig. 10): actual car cycle in an industrialised country where diffused motorisation has already taken place*

train arriving at a station, according to a timetable, compliant with one's own needs. ITS now allows the *physical* position of a vehicle to be known not only through direct experience, its ownership, or a timetable, but also through *information*. One can know that a sharable vehicle is available next to one's office and is free to be used. Therefore, should the *ownership* of a vehicle be renounced in order to use a shared and connected one, according to reliable information concerning its physical position and availability? This issue opens the market towards *Mobility as a service*, which is also known as Maas, especially in urban contexts, where mobility and the number of vehicles are at a maximum, in terms of frequency and density, and travellers use services for transportation, such as public transport and car or bike sharing, rather than availing themselves of personal vehicles.

Such a Maas might imply that the production of private vehicles could change in the future as the result of the introduction of a shared economy of vehicles, where the buyers would typically be large companies or public administrations. This would imply another relationship with Kondratiev waves, i.e. even a much smaller wave, somehow emerging in [38], though not referred to as a Kondratieff wave but to private ownership and its relationship with Internet development, in its various declinations. According to the authors of this paper, *property* is something that is closely related to human beings, who renounce it mainly for economic reasons; therefore, the fact of not having the possibility of affording a connected green vehicle, such as an electric or more flexible plug-in hybrid one, might induce the development of a stronger shared economy of cars, so that *sharing* could be interpreted *as a vector towards future property* of such modern cars; however, this possibility does not seem to change the concepts presented in this paper. In fact, ITS can be the key to the evolution, but if ITS is a tool for this evolution, the economy will most probably increase to satisfy new modern needs, mainly related to providing more free time to travellers (through assisted and autonomous vehicles), to respecting the environment (through green vehicles) and to having the possibility of interacting with other people or working during movement (through connected vehicles).

5 Conclusions

Several recent developments (1990–2016) have made motionless communication appealing, but the one that might outclass motorised mobility and physical movement is the ability to multitask. When using a computer, it is possible to video call a colleague or a friend and, at the same time, share multimedia files, or buy goods on a website on the opposite side of the world. In reality, even though motionless communication can be extraordinarily helpful and pleasant, it can never completely replace motion-full communication or motorised mobility. People still need to physically move, whether by motorised means or not, and will probably always need to. Travelling will surely decline until integration will perhaps occur with motionless communication, a fusion that ITS pursue. In a not too distant future, the two types of communication will surely collaborate to improve each other and the lives of people. In this way, physical movements – even if the increase of speed of land-based transport systems has seen some limitations - could be optimised and made more time-effective, but also safer, with higher efficiency and quality.

Consequently, transport infrastructure networks as well as motor vehicles – with *green* traction, connected, with assisted driving, then possibly with autonomous cars where viable – should be adapted through ITS to support this upcoming diversified communication. In short, on the basis of what has been explained and shown in this paper, it is hoped that the present decline in motorised mobility, as far as it can appear so nowadays, is just a sign of what the next Kondratiev cycle will involve: a new and innovative way of communicating – with movement in physical and in virtual spaces – which Man will use to improve himself, to rise and evolve again, using technology to improve motorised mobility, through ITS.

6 References

1 Ericsson – Telefonaktiebolaget LM Ericsson, Traffic and market report – on the Pulse of the Networked Society, June 2012
2 Marchetti, C.: 'Anthropological invariants in travel behaviour', *Technol. Forecast. Soc. Change*, 1994, **47**, pp. 75–88
3 Marchetti, C.: 'Infrastructures for movement: past and future, chapter 7 in 'cities and their vital systems: infrastructure past, present, and future', *Natl. Acad. Eng.*, 1988, pp. 146–174
4 Marchetti, C.: 'On Transport in Europe: the last 50 years and the next 20, Report of the First Forum on European Transport in the Future', 1988
5 Zahavi, Y.: 'Synthesizing a transportation study by the 'in' Procedure, Technodaf, 1972
6 Marchetti, C., Ausubel, J.H., Meyer, P.: 'Toward green mobility: the evolution of transport' (European Review, Published by Cambridge University Press, UK, 1998)
7 Marchetti, C., Ausubel, J.H.: 'The evolution of transport, from 'the industrial physicist' (Magazine published by the American Institute of Physics (AIP), 2001)
8 Axsen, J., Kurani, K.S.: 'Hybrid, plug-in hybrid, or electric – What do car buyers want?', *Energy Policy*, 2013, **61**, pp. 532–543
9 Jensen, A.F., Cherchi, E., Mabit, S.L.: 'On the stability of preferences and attitudes before and after experiencing an electric vehicle', *Transp. Res. D Transp. Environ.*, 2013, **25**, pp. 24–32
10 Metz, D.: 'Saturation of demand for daily travel', *Transp. Rev.*, 2010, **30**, (5), pp. 659–674
11 Plötz, P., Schneider, U., Globisch, J., *et al.*: 'Who will buy electric vehicles? Identifying early adopters in Germany', *Transp. Res. A Policy Pract.*, 2014, **67**, pp. 96–109
12 Pucher, J., Peng, Z.-R., Mittal, N., *et al.*: 'Urban transport trends and policies in China and India: impacts of rapid economic growth', *Transp. Rev.*, 2007, **27**, (4), pp. 379–410
13 Van Rijnsoever, F.J., Hagen, P., Willems, M.: 'Preferences for alternative fuel vehicles by dutch local governments', *Transp. Res. D Transp. Environ.*, 2013, **20**, pp. 15–20
14 Ziegler, A.: 'Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: a discrete choice analysis for Germany', *Transp. Res. A Policy Pract.*, 2012, **46**, pp. 1372–1385
15 Franke, T., Krems, J.F.: 'What drives range preferences in electric vehicle users?', *Transp. Policy*, 2013, **30**, pp. 56–62
16 Hjorthol, R., Vågane, L., Foller, J., *et al.*: 'Everyday mobility and potential use of electric vehicles', TØI Report, 1352/2014, Paper version, Electronic version Oslo, 2014
17 Le Duigou, A., Guan, Y., Amalric, Y.: 'On the competitiveness of electric driving in France: impact of driving patterns', *Renew. Sustain. Energy Rev.*, 2014, **37**, pp. 348–359
18 Pearrea, N.S., Kemptona, W., Guenslerb, R.L., *et al.*: 'Electric vehicles: how much range is required for a day's driving', *Transp. Res. C Emerging Technol.*, 2011, **9**, (6), pp. 1171–1184
19 Deflorio, F., Wuo Lopes, M.: 'High-speed railways as an alternative for air transport in Europe/ La rete ferroviaria ad alta velocità in alternativa al trasporto aereo su scala continentale Europea', Ing. Ferrov., Ed. CIFI, 2010, **11**, pp. 985–1000
20 Di Majo, F., Elia, A.: 'Le tappe dell'alta velocità'. Ingegneria Ferroviaria, CIFI, April 1991
21 Meeker, M.: 'Web 2.0 summit slideshow: internet trends' (San Francisco, 2011)
22 Dalla Chiara, B.: 'Sustainable transport systems: trends on needs, constraints, solutions'. E3S Web of Conf., Science and the Future, Article Number 03003, Section Human Societies, 2014, vol. 2, p. 10
23 Organisation for Economic Co-operation and Development, ITF Transport Outlook 2013, OECD iLibrary, 2013
24 International Energy Agency, CO2 emissions from fuel combustion, 2010
25 European Commission: 'EU Energy Transport and GG emissions trends to 2050, Directorate-general for energy, directorate-general for climate action and directorate-general for mobility and transport, 2013
26 U.S. PIRG Education Fund and Frontier Group: 'Transportation and the new generation', 2012
27 Sivak, M.: 'Has motorization in the U.S. peaked? Part 6: relationships between road transportation and economic activity', Report N. UMTRI-2014-36, 2014
28 Hop Associates and Transportation Research Group (University of Southampton), Impact of information and communications technologies on travel and freight distribution patterns, 2002
29 Fridstrøm, L.: 'Norwegian transport towards the two-degree target: two scenarios, Ministry of the Environment – Oslo, December 2013
30 Frontier Group: 'Transportation and the new generation', U.S. Pirg Education Fund, 2012
31 Kellerman, A.: Daily Spatial Mobilities, Ashgate, 2012
32 Casaleggio Associati, E-commerce in Italia, 2013
33 OECD (Organisation for Economic Co-operation and Development): 'Long-run trends in car use, OECD iLibrary', 2013
34 OECD (Organisation for Economic Co-operation and Development): 'The internet economy on the rise, progress since the Seoul declaration, OECD iLibrary', 2013
35 Kondratjew, N.D.: 'Die langen Wellen der Konjunktur. Archiv für Sozialwissenschaft und Sozialpolitik., 1926, 56, pp. 573–609
36 Axsen, J., Orlebar, C., Skippon, S.: 'Social influence and consumer preference formation for pro-environmental technology: the case of a U.K. workplace electric-vehicle study, in Ecological Economics, 2013, 95, pp. 96–107
37 Van der Waard, J., Jorritsma, P., Immers, B.: 'New drivers in mobility; what moves the Dutch in 2012?', *Transp. Rev.*, 2013, **33**, (3), pp. 343–359
38 Goodwin, P., Van Dender, K.: 'Peak car' – themes and issues, transport reviews, 2013, **33**, (3), pp. 243–254