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"Fusion Mobility" – Discovering the Mobility-DNA of Inclusive Cities

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Abstract:

Since introduced from September 2017, Fusion Mobility has launched an academic and practitioner discussion about a new sustainable mobility architecture that sets out to fill gaps in our future world of transport, urban design and beyond to society in general. (1) It is bridging the social and the technical world; (2) it provides an approach for handling benefits and risks of AI (Artificial Intelligence) in the context of connected and autonomous mobility; and (3) it is taking the strengths of ITS methodologies and merging them with parallel developments in Active Mobility and Sustainable Development to ensure further improvement of inter- and multimodal solutions for seamless transport and quality of life.

This paper discusses what Fusion Mobility as a systemic approach can contribute to make cities and regions more inclusive, firstly according to all aspects of people's accessibility and social inclusion, but also on the environmental and economic aspects. It is necessary because in the near future existing policy initiatives will have already inaugurated dramatic changes in mobility systems. For example, the use of driverless cars and the phasing out of internal combustion engine vehicles will have significant effects on mobility systems.

Although many aims and objectives are shared the fragmentation of the different academic and practitioner communities can lead to conflicting objectives, language and approaches, which undermine the potential of both. In particular policy makers at all levels need to be able to make informed choices about the development of future mobility, which maximise both human and technological benefits. Fusion Mobility is prioritising Active Mobility, as Active Mobility approaches are delivering high economic, social and environmental benefits, with cycling alone identified as contributing to 14 of the 17 United Nations Sustainable Development Goals.

Therefore, the Fusion Mobility frame of sustainable development can accelerate adoption and acceptability of new approaches and will maximise collaboration between all actors who favour Active Mobility.

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1. Introduction

Fusion – "the process or result of joining two or more things together to form a single entity".[1]

This new, overarching approach is used to overcome the risks and challenges, and promote the opportunities of the digitized economy, connected mobility and artificial intelligence – here we categorise AI as machine learning.

Fusion Mobility is an Active Mobility based concept for future multimodality and inclusive cities. It is people centred, future oriented and aims to release the full potential of connected mobility for all – but also to avoid that artificial intelligence and the related digitized economy will not bring about "the great divide"[2]. *Fusion Mobility* is intended to foster inclusion and improve all modes of transport. **Table 1** will draft orientation questions concerning these challenges to guide the discussions. Thus *Fusion Mobility* is intended to foster inclusion and help all people.

Fusion Mobility is an interdisciplinary approach to intelligent transport planning bringing together engineers, urban and transport planners and social researchers together. *Fusion Mobility* takes into account the high positive impacts of Active Mobility and sustainability according to the SDGs, the United Nations Sustainable Development Goals, it fosters existing methodologies such as ITS and other digital innovations. The new relationship is drafted in **Table 2**. This is to ensure that for example ITS systems in transport and beyond make a maximum contribution to future sustainable

urban and transport development and in particular to social qualities of life.

The main reasons for launching *Fusion Mobility* (FM) arise from firstly being widely not recognised, but unleashing incredible power and sustainable effects when introduced practically in cities like Copenhagen. Secondly it is about facing social frictions from transport systems that may even increase through new technologies like Autonomous Vehicles and steering systems based on artificial intelligence. Thirdly it is about dealing with intermodal and multimodal concepts in ITS approaches and beyond, where problems in operating and freeing its potential must be recognised – which will be examined throughout this paper.

Fusion Mobility was first introduced and discussed at the 8th Travel Demand Management Symposium at NTU Taipei, September 27, 2017.[3] Since 2018 is the "Year of Multi-Modality" for the European Union, the global cycling Summit Velo-city 2018 has the motto "Access to Life", and also because the ITS World Congress of 2018 is in a popular cycling city of Copenhagen this alignment provides an opportunity to stimulate debate and move to the next stage in developing this debate. Thus, already now, the introduction of "*Fusion Mobility*" as a concept has launched academic and practitioner discussions in the world of ITS and abroad.

In particular, it is the right time now to introduce Active Mobility concepts and opportunities, as this will be outlined in chapter 2, and to introduce it into the further deployment of ITS and similar as a tool for sustainable development. Furthermore, it is about transformation and change for sustainability, and to overcome the temptation of imposing new technologies on human behaviour from many promoters of new approaches to urban development without thinking through consequences for sustainable development.[4] The methodological approach therefore will be explained in chapter 3.

The strengths of Fusion Mobility is the integrated approach for a systemic mobility concept, drafted in chapter 4. All means of transportation are represented, while human needs and rights are prioritized, and the numerous benefits of *Active Mobility* (AM) can be unleashed[5]. In chapter 5 some perspectives for further research and to guide sustainable mobility development are drafted.

However, there are a number of challenges to be overcome along this path, which is why a number of orientation questions shall be raised in advance of the further discussions:

Table 1 Orientation questions for *Fusion Mobility* focusing on social impact and also artificial intelligence.

1. The fear of people
- Do we really like to be connected?
- Do we fear losing our autonomy in competition with autonomous cars?
- How much privacy will we lose in the digitised and Artificial Intelligence (AI) driven future?
- Is this the inclusion we want to have?
- Will we understand our world, or will we get many new "black boxes" we don't understand?
- If we do not or do not want to use the new communication tools, will we get socially isolated?
- Will we have to pay for what we didn't order?

2. The hope of experts
- Can we optimize the benefits for people being connected (*Users first principle*)?
- Can we manage the delicate balance of using as much data for steering and using as little data as necessary (*Big data challenges*)?
- Can we interlink vehicles and systems to unleash the benefits of multimodality (*ITS approach*)?

3. Consequences of emerged Artificial Intelligence (AI)
- Are we able to control AI consequences for society?
- Will we only optimize existing systems with AI (e.g. individual motorized transport systems), or will we also have leeway for evolutionary systemic development (holistic approach)?
- Will we create ethic-social problems without further opportunities to control and readjust them?

These questions will come up in many discussions, and we will meet some of them in the next chapters to deliver more food for thought for further discussions.

At the end of the paper you will find **Table 3**, a **glossary** of terms and paradigms of this paper with abbreviations and definitions can be found.

2. Opportunities

2.1. The human scale of Active Mobility

Basic human needs are justifying Active Mobility (AM). "In the beginning of humanity was the upright gait. Walking on two legs is a definitional condition for homo erectus. Walking was the precondition for the evolution of the human brain and of homo sapiens. Human beings are intrinsically conditioned to be physically active."[6].

AM is the opposite of the fuel or electric power driven Passive Mobility (PM). And it is absolutely different to "Non Motorized Transport (NMT)".

In the development of car-centred development the term NMT was coming into use as the self-explanatory contrary of "Motorized transport". Psychologically from the very beginning it made motorized transport the normal and positive mode, and increasingly a common notion that NMT is not the normal and – according to the term – negative[7]. Furthermore, it was limiting meaning and value of the active modes, which is mostly walking and cycling, as transport only.

Since the Active Mobility (AM) approach was launched between 2008 and 2010[8] all the other aspects and benefits of the active modes beyond transport have been recognised more systematically, in particular with the development of the Active Mobility Agenda (AMA).[9]

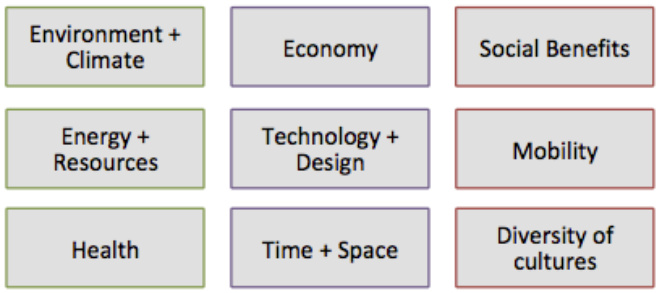


Fig. 1. *The Active Mobility Agenda*

AMA has already become a tool used to identify the economic benefits of cycling [10], and has been used in evaluating how cycling and Active Mobility contributes to the UN Sustainable development goals (SDGs)[11]; (see *2.2.*).

From the very beginning the AM concept was understood as being able to incorporate all modes of land transport for inter- and multimodal use as well as including intelligent transport solutions. The importance of this Active Mobility approach was to frame the human scale in transport, and not to neglect the basic essentials for any intelligent transport solutions.

The Active Mobility pyramid[12] explains the ideal and complementary structure of AM and PM.

A major development is the new role and function of Electric Powered Assisted Cycling (e-cycling/pedelecs) as a hybrid of AM and PM with high potentiality of range extension and comfort. A term "Active E-mobility" also can be discussed, as e-cycling/pedelecs are the fastest growing part in the entire field of individual e-mobility.

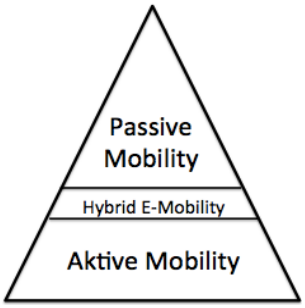


Fig. 2. *The Active Mobility pyramid*

On range extension the leap forward is as it was from walking to cycling. Additionally, studies confirm that the hybrids retain the positive health effects of AM[13].

For longer journeys we need energy support from different sources (e.g. fossil, electric, even animals' power). This is where we appreciate the vehicles of PM (e.g. aircraft, ships, trains, buses and cars). Short distances (mostly) can be done by AM (including e-cycling/pedelecs).

2.2. The Scale of the Opportunity

AM provides a unique opportunity as it affects the movements and habits of the population at the exact points where they start and end trips, where they make purchases, where entire city centre economies function, and where social life is most intensified. This economic impact is important in times where increasingly money goes through the internet.

AM provides the feeder populations for public transport and driving. This group is more diverse demographically than motorized users and more flexible in its behaviour than public transport users. Potential Big Data collection enables us to analyse the behaviour of disaggregated groups of citizens at a street-by-street level, and to leverage public policy interventions to maximise sustainable behaviours. These approaches are delivering high economic, social and environmental benefits, with cycling alone identified as contributor to 14 of the 17 United Nations Sustainable Development Goals[14]. ITS methods that support these approaches will maximise their impact on quality of life.

In demographic terms Active Mobility reaches a significant population that is unreachable by other sources of transport because they do not purchase tickets or drive connected vehicles. In Europe 40 million adult citizens cycle daily and a further 78 million cycle at least once a month[15]. In cities like Copenhagen cyclists form over 30% of daily travellers[16], so any ITS deployment that does not include cyclists is missing the largest traveller group in a city, a situation that may require the city to redesign all its transport modelling tools.

Copenhagen is a living case study for Fusion Mobility. Its urban form has been re-shaped by one of the leading global voices for a new way of designing cities, Jan Gehl[17], while its mobility has one of the highest levels of daily commuter cycling of any city in the world. This success is based on long-term progress with huge impact and diversity, nobody else as Jan Gehl himself explained most recently in five phases from the 60ies until nowadays[18].

Another important development is underway currently with the rapid market growth of Pedelecs (Pedal Electric Assisted Cycles/e-cycles). Sales in the EU were around 1.7 million in 2016, rising steadily from 500,000 six years ago[19]. Cycling is now an alternative transport choice competing with cars and public transport in the 20km journey range and the fastest growing sector in electric mobility in the EU. The numbers of pedestrians are even higher, but they are even less well defined, but almost all trips include at least one section of walking even if only from parking point or terminal. Many of these trips are associated with commercial purposes.

To improve sustainable mobility and for cycling development it was a great success when the European EPAC regulation for *Pedelecs as bicycles* came into force[20] in 2009. Not knowing about Fusion Mobility, with this practical EU policy already three of six key-elements of Fusion Mobility had been fulfilled (as described in chapter 4 *Active Mobility*, *EcoMobility* and *Future Vehicles*). Unfortunately this is threatened by the current EU commission (EC) proposal to amend the Motor Insurance Directive (MID), which would mean that pedelecs would be classified a 'motor vehicle' and therefore users without third party motor vehicle insurance would be riding illegally.[21] Another example like this is the proposed VAT directive, which would favour electric cars by allowing reduced VAT for them, but not supporting pedelecs in the same way[22] – according to human (health) needs and rights[23] it should be the other way round.

With these proposals the EC is undermining their own success in active e-mobility, and furthermore the development of sustainable mobility in Europe.

With these prominent examples the scale of the Active Mobility based transformative value of *Fusion Mobility* becomes very clear, and it leads directly to the enormous opportunity of *Fusion Mobility*.

2.3. The Opportunity of Fusion Mobility

If there are tensions in the development of cities as a resource for Active Mobility and building quality of life, what are the opportunities? What decision makers and ITS planners need to bear in mind when thinking about Active Mobility is to frame this in the context of 'change':

- Change from dependency on low occupancy internal combustion engine powered vehicles, offering choices that function as well as support equality and sustainability.
- Allowing mobility and economies to function while removing motor vehicles from public space and enabling its reallocation for people, for economic activity, and for social interaction.

Starting with the things we have in common as an ideal model, it is possible to create a systemic mobility concept. We know about the elements like infrastructure, human needs and behaviour, vehicles etc. that will play a role in this ecosystem. However we can also consider what we do not want. Neglected human needs and fragmented modes of transport work against systemic mobility systems and quality of life. Building positive connections will create the best shared "Fusion" of all objectives.

The common ground can be illustrated in the table below, which shows the role of some ITS tools in enabling Active Mobility and creates an opportunity for Fusion Mobility.

- MaaS and multi-modality without cycling and walking.
- Proposals to test automatic vehicles in spaces that are already vehicle free – cycle lanes, car free zones; or suggested removal of cyclists and walkers from preferred routes for new vehicles.
- Modelling tools that fail to factor health into cost-benefit analysis for MaaS, Automated vehicles, C-ITS, ITS and so do not have complete data sets on economic value of Active Transport, failure to factor health into cost-benefit.
- Taking a victim-centric approach to vehicle management instead of holistic solutions to enable Active Mobility. As raised in 2.1, there is a strong objection to the historic terms "Non-Motorized Users" and in the same sense it is to "Vulnerable Road Users" by practitioners in Active Mobility (as expressions of low status).
- Policy makers focusing (funding and policy) on future Automated Vehicles rather than working on successful and proven technologies like Intelligent Speed Assistance and detection/braking/warning systems.
- Reinforcement of "business as usual" including approaches that place vehicle flow as a higher priority than people flow.
- Managing vehicle flows for higher speeds at the expense of environmental and safety impacts.
- The suggestion that "Smart Cities" would be better framed and developed as "Wise Cities" in order to better value the human outcomes expected over technological.

Table 2 A new relationship of Active Mobility and ITS[24]

Active Mobility and new urban form approaches	Supportive ITS approaches included in Fusion Mobility
Create conditions for behaviour change by individuals – choosing alternative transport modes and combined mobility trips using intermodality.	ITS tools that provide choice (e.g. MAAS) or incentivise change (gamification) are strong additions to the Active Mobility toolbox. And bringing incentivisation into MaaS making visible within journey planning the often quicker A-B journeys of cycling.
Support the new paradigm for public space in cities and for recreation – free from private motorised vehicles	Enabling alternative access to city centres and public space without cars, using inter-modal choices or automated vehicles to keep cars outside the city core ITS enabling a new approach to freight deliveries – scheduling deliveries outside vehicle free hours
Improve access to mobility choice, making alternatives universally available, for example by shared mobility tools and by better availability of information of multimodal services	ITS providing the platform for sharing services and enabling pricing systems that can support discounting for targeted groups – low income, disability, children, etc. Supporting sharing solutions in geographically remote zones.
Create conditions for investment by public bodies and transport operators	ITS providing data on mobility preferences and cost benefit for planning infrastructure, parking, routing and promotion
Reduce both real risk and perceived danger so that the barrier of safety fear is reduced, encouraging choice of Active Transport and Public Transport	ITS providing route choice, sensing, alarms, vehicle management, infrastructure management (eg. smart lighting) and monitoring. Enabling speed reduction vehicle technologies and incorporating cycling/walking detection systems.
Improve traffic management to allow the flow of vehicles as needed, but favouring sustainable choices such as Active Transport users, combined mobility and electric mobility (especially hybrid electric human power such as e-bikes)	ITS supporting new road management hierarchies that give preferences to specified vehicle types and manage them by exclusion (geo-fencing), by time changing priorities, by charging and by automation such as automatic speed limiting. C-ITS GLOSA and re-routing to manage traffic flows

This approach challenges providers to create truly seamless transport and multimodal solutions. But we are not starting from zero – there are already excellent cities and regions where it currently works well.

However, there can be (and are) many ways of not conforming to this healthy relationship between Active Mobility and ITS including:

3. Methodological setting

We can highlight approaches that emerge from ITS solutions that are seen to contradict principles of Active Mobility and Sustainable Urban Development, and which cause frictions with political and practitioner stakeholders trying to implement best practices. Where there is

disagreement with the approaches emerging from ITS, it is often around language and apparent motivations – much of which can be analysed through "Framing".

3.1. Framing

Framing as a methodology is used and consequently adopted here from the scientific framework of decision theory and the psychology of choice according to Tversky and Kahneman[25], and to related concepts of mental models as from Denzau and North[26], introduced to Transport by Schindler et al.[27]. For Active Mobility these concepts have been used by Held et al.[28] and Neun[29].

Based on this approach, the methodological concept for this review and discussion paper has been a limited literature search supported by expert knowledge and expertise from practitioners in the key transport sectors of AM, taking into account expertise and development from over the last decade. This framing also include the approach named *The City we want*, based on ITS, taking all that we currently know, from all means of transport (e.g. Lehmann[30]), all current and – anticipated – future technologies, and accepting complexity from cognitive and social sciences. In result this creates a wider frame as we may find it in current technology centred strategies as for example the "Strategic Transport Research and Innovation Agenda (STRIA)".[31]

3.2. Paradigms for Fusion Mobility

The reframing needed for ITS and other planning approaches to become Fusion Mobility, demands that ITS innovations reflect the academic and practical development of sustainable mobility. There must be access to all the benefits from the sustainability 'trio' of environment (clean air, less pollution, etc.); the social dimension (inclusion, civic welfare, etc.); and economy (green growth, societal benefits, etc.). This means looking beyond technical solutions and understanding the thinking that underpins and guides the development of urbanism and Active Mobility. Some of the current fields are well understood in ITS practise, for example Shared Mobility and Connected Mobility, but they are not yet (re-)framed in the context of Active Mobility, Placemaking, EcoMobility or similar paradigms.

When applying the *Fusion Mobility* (FM) approach it is useful to match sustainability with quality of life for all. For ITS this means prioritising human needs and rights according to the UN Sustainable Development Goals (SDGs)[32] in front of technical solutions. Technical forms, formats and innovations are following and serving human functions. The restructuring proposed by Neun is that the following elements compose a bundle to create a ***holistic mobility system (Fusion Mobility)***. Not independent from each other, these elements are intimately connected.

The six key-elements considered by Neun and collaborators at this stage of the development of *Fusion Mobility* are

- Prioritising Active Mobility;
- Placemaking – democratising public space;
- Enabling shared mobility;
- Facilitating the EcoMobility approach;
- Integrating future vehicles and interlinked infrastructure;
- Connected Mobility for all means of transport.

3.3. Telic orientation – guidelines for further research and assessments

The reframing needed for ITS to become Fusion Mobility demands that ITS innovations reflect the ethical, academic and practical development of sustainable mobility with guidelines to achieve these additional challenges.

The elements of *Fusion Mobility* has their specific telic orientation[33], meaning that all the elements are intended to reach goals or even goal bundles as discussed from cognitive and linguistic research. Taking the element of AM as an example: Telic means to prioritize *Active Mobility* (AM), anti-telic the opposite, explained as *Passive Mobility* (PM). This can be seen in 4.1., but the telic principle is relevant for all elements and the systemic interaction of all of them.

Another example comes from the goal 'people centred', which we can meet quite often in speeches. Without a telic orientation it will remain a phrase with no substantial effects.

According to that, the *Fusion Mobility* concept with six paradigms is intended to target clearly

- A systemic approach, with key-elements being connected with each other;
- A people centred system;
- Including, not avoiding complex, telic[34] scenarios;
- Focusing quality-oriented, robust, resilient and sustainable ITS;
- And enabling suitable means and tools to achieve future ITS objectives.

What are *car-centred cities* to be categorized in this context?

Although the polar opposite of AM, they are not singularly PM orientated neither, as this category includes all motorized *Public Transport*. This means we have to be aware of three important methodological aspects:

- In framing the overall mobility issue, there must be three pillars in: AM, PM and motorized individual transport. They must be all represented for *Fusion Mobility*, but AM has to be prioritised in a complementary scenario.
- Framing the telic / anti-telic scenario we cannot accept that AM is a synonym of the well-established term "Non-motorized-transport".

Faming sustainable development we have to acknowledge that reducing non-sustainable behaviour is reducing non-sustainability only, but not creating sustainability from bottom up.

In the following chapter, the six elements of *Fusion Mobility* are named Building Blocks (BB).

4. Building Blocks for Fusion Mobility

4.1. Prioritising Active Mobility

It is well understood that cities are congested with motorized transport, about the associated social and environmental costs[35]. We also understand the price of inequality in general,[36] as well as from an urban and transport perspective[37]. We also know about the huge benefits of physical activity and in particular of AM, we know about the

benefits for health, the environment, and social life[38] [39]. All these benefits were framed as an overview by nine key-issues in the Active Mobility Agenda (AMA), which has been used to evaluate how many of the UN 2015 Sustainable Development Goals (SDGs) cycling contributed to. The result: walking and cycling contributes to 14 of the 17 SDGs[40].

Secondly, the overall socio-economic benefits of cycling in Europe have been evaluated based on AMA, resulting in an estimation of 513 bn Euro per year in Europe on the current state of cycling mode share[41]. This creates not only a development tool for sustainable transport, but for green growth in general[42]. The highest benefit came from health, with all the diseases of our sedentary societies that start in early childhood. And it is in health that we see huge positive benefits when translating the economic benefits with a large shift to cycling[43].

And finally, with the current inventions in cycling and the interlinked infrastructure (see 4.5), we have many modern tools and current best practice to demonstrate how fast the active modes can be increased when prioritized.

Benefits and the global demand for contributions on sustainable transport are high[44]. "To deliver Sustainable Mobility for All, we must integrate project-level impact evaluation to generate evidence for proper design of project and policies, allowing us to focus on transport interventions that provide the highest returns for equitable, efficient, safe, and green mobility" as quoted by Walid Abdelwahab, Director of Infrastructure, Islamic Development Bank.[45]

TakeAway 1 – *Priority for Active Mobility*

Many good reasons and evidence support prioritising AM; and AM, and in particular cycling, contributes greatly to the UN SDGs (14 of 17 Global Goals), evaluated substantially in particular by the AMA.

4.2. Placemaking – Democratising public space

"Placemaking is a multi-faceted approach to the planning, design and management of public spaces. Placemaking capitalizes on a local community's assets, inspiration, and potential, with the intention of creating public spaces that promote people's health, happiness, and wellbeing. It is political due to the nature of place identity. Placemaking is both a process and a philosophy".[46] Emerging from a new approach to urban design and public realm in the 1960s Placemaking has become an umbrella term for a new way of thinking about urban form. It includes both city centre vitality but increasingly includes approaches to neighbourhoods and suburban zones, using concepts often labelled as "accessibility", "liveability" and "quality of life".

The reason behind this emergence has been firstly to overcome the dominance of the car in public space, and not to limit future integrated mobility by further fragmentation. Secondly it is about the development of combined mobility and the importance of public space: "The reorganisation of public transport and combined mobility services needs to be planned carefully and efficiently in order for any pedestrian zone to successfully meet its goal of improving the quality of life in the city centre".[47] In urban design Jan Gehl introduced the principle "Cities for People",[48] where public life must be the driver for *Urban Design*.[49]

Furthermore, as Steffen Lehmann told, we also "should remember that cities were never intended to be completed. Any city is inherently evolutionary, in constant transformation, and much in its character lies in the complexity and diversity of its urban spaces".[50] This has substantial consequences when discussing solutions based on *segregation* vs. *mixed and shared zones*, or *partitioning* vs. *flexibility* in public space. Following the Lehmann reminder, we clearly should give priority to the flexible solutions whenever possible. Of course this will stimulate another discussion on road safety, as the promoters of segregation claim to offer the safer option. Many, may be even more case studies have been made under segregated conditions.[51] More diverse studies we can see when related to age and gender[52], but in general we know that in given spatial and regulatory structures safety is a result of adaptive behaviour. According to that let us also take seriously into account the EU 30km/h recommendation[53] and the safety benefits from there.

From all points of view – planning, decision making, investing, setting up rules and regulations – the utilisation of rare *public space* by vehicles must respect the right of access and usage for all people[54], and then the vehicles in the order of size and sustainability; thus it needs fair prices for the use by different modes and vehicles (this includes internalising the external costs across all modes of transport). "The reorganisation of public transport and combined mobility services needs to be planned carefully and efficiently in order for any pedestrian zone to successfully meet its goal of improving the quality of life in the city centre".[55]

TakeAway 2 – *Public space*

There is evidence that prioritising AM would revitalise and provide fairer and more efficient access for all to public spaces.

4.3. Shared Mobility

Shared Mobility can be understood mostly as a hybrid solution in between private (active and passive) vehicle ownership and public transport; demand driven and transport capacity building oriented by sharing the vehicle (car, bike, vans, …) or travel (ride sharing), plus sharing costs.

Most important for *Shared Mobility* in current development is TAAS[56] or MAAS[57] (Transport or Mobility as a Service), as it has the potential to initiate a shift away from personally owned modes of transport towards mobility services (more in pt. 6 *Connected mobility*). This could be ground breaking and has already had positive consequences for leveraging space capacities (less vehicles and shared space) and reducing emissions compared with private individual vehicles. And it has positive consequences for *Public space* becoming public again, equitably shared and accessible for people.

The fastest growing type of shared mobility worldwide is *public cycling.* [58] Additionally to the fast increase of the well-known Public Bike Share with docking stations, there was almost an explosive growth with dock-less sharing bikes, flooding public space.[59] Therefore they were also called free-floating bike share (FFBS) or in US even

"rogue bike shares" we should provide some thoughts on this new phenomenon related to AM and public space:

The systemic understanding of Shared mobility is not only a transformation of transport, it is a new business bringing many new and old actors in this field together.[60] However there is the possibility that we move from congested private car roads to congested shared car roads. MaaS should be managed, otherwise it will set back cities sensitively by one or two development phases[61] with regards to sustainability, improved health, air quality, congestion, modal shift to sustainable modes etc. There is huge potential with MaaS to contribute to modal shift to AM. Having all modes of transport on one platform with one mode of payment, could provide imaginative ways for cities (or the private sector) to provide incentives or disincentives to take various modes of transport.

TakeAway 3 – *Shared mobility*

All public shared modes of mobility are consistent with all other elements and effecting *Fusion Mobility*, while private services called "shared" will expose themselves quite often as not people but business/shareholder centred. Increased shared mobility will contribute to better transport efficiency according to all sustainability dimensions, economically, social and environmentally. Thus, the systemic understanding of shared mobility is essential for future ITS.

4.4. The EcoMobility approach

"EcoMobility means subsidiarity in urban mobility and transport. It presents a bottom-up approach to setting a priority order for the individual choice of transport modes as well as for urban planning and investment". The current EcoMobility hierarchy "gives priority to walking, cycling and using shared and public transport" in this order[62]:

1 – Walking; 2 – Cycling and wheeling (travelling trolleys, prams, little carts etc.); 3 – 'Passenging' (using public transport); and 4 – Car-sharing[63]. The later in a broader sense including ride sharing, hailing etc.

And finally individual motorized transport – 5 – will then have the lowest priority in this complementary system. The variety of future vehicle will be described and discussed in BB 5 (see 3.4). E-bicycles/pedelecs will be consequently and completely in the cycling category.

Furthermore, EcoMobility "promotes travel through integrated, socially inclusive and environmentally-friendly transport options without depending on privately owned motor vehicles. By enabling communities and organizations to access goods, services and information in a sustainable manner, EcoMobility supports citizens' quality of life, increases travel choices, allows for use of public spaces and promotes social cohesion".[64]

EcoMobility produces significant results in energy savings and CO2 reductions. Overall EcoMobility is a holistic approach to contribute to the UN Sustainable Development Goals (SDGs), and was aligned to the ICLEI Kaohsiung Strategies for the Future of Urban Mobility.[65]

ITS is a promising set of measures for EcoMobility with ideas like **TOD** or **TDM**. TOD ("*Transit Oriented Development*) as it is an established approach in urban development that optimizes urban concentration to walkable distances to public transport (PT). Furthermore it highly depends on PT-logistical and AM-infrastructure development. We also see here a high TOD-internal development and an increasing diversity of approaches.[6667]TDM ("*Travel Demand Management*") as developed with strategies that result in more efficient use of transportation resources[68] also has great promise in the use of ITS, in particular for improving sustainable transport use,[69] but to create a more sustainable urban reality, a paradigm shift is needed in the direction of the EcoMobility approach.

TakeAway 4 – *The EcoMobility Approach*

The hierarchic order of EcoMobility is widened by prioritizing AM within a structured hierarchy of five levels, where all elements of sustainability according to transport modes become consistent. In the FM extended EcoMobility concept, planners and ITS engineers will get systemic access to future ITS – a significant step forward from segregation and competition of the modes of land transport to people and FM induced integration, and to 'wise' cities.

4.5. Future Vehicles and interlinked infrastructure

Future vehicles will show a much broader variety of formats, with self-driving cars, driving-assisted vehicles, light vehicles, many hybrids on different criteria etc. The interesting question for future intelligent solutions will be, if they will be adapted better for different needs and demands, fully prepared to saving energy and avoiding emissions, allowing increasing active mobility. For example we may see more light vehicles, not only fully electric (PM) or driven by other energies, but in particular as three and four wheel e-hybrids (AM/PM electric assisted vehicles)[70]. In general, Pedelecs and Speed-pedelecs[71] will play a substantial role due to their extended reach.

The existing technical world of transportation is dominated by technical solutions. But at the same time we have a serious lack in infrastructure for all modes of transport. Thus, we do not have the infrastructure we would like to have for ITS, and for quality of life solutions for the future. Therefore we will need a more integrated infrastructure planning and investments for all means of transportation, in particular for smart and safe connected transport systems. This brings us to ask for *Intermodality* (or multimodality) which is essential for ITS, and also related to TOD and TDM results.

A genuine intermodality will always need to incorporate walking, as walking is a binding factor for the use of vehicles – people normally cannot drive by car to the front of their bed. And if walking is essential for *intermodality*, AM is already confirmed as essential and not negligible. Therefore AM has to play an integral role and not be downgraded as a sub-tool or an "assisting" means of other transport categories (as this has been the belief of many transport planners and even researchers).

Confirming AM as an integral part of intermodality should also lead to the inclusion of cycling, pedelec use, public bike share and other "Smarter Cycling" solutions. If a strong systemic development will be introduced, this may lead to pro-sustainability collaborations between Public Authorities on all levels, e.g. transport, health, environment,

climate etc. ITS planning for all modes and mobility functions as described in 2.1 – 2.4 means creating a well-balanced infrastructure for all these modes and functions.

TakeAway 5 – *Future vehicles and interlinked infrastructure*

This building block is to achieve a well-balanced infrastructure delivering access for all people and the frame for future vehicles. The increasing variability of vehicles and infrastructure can lead towards vehicle-orientation, but it is here the people centricity of FM can act as a corrective.

4.6. Connected Mobility

Connected mobility is about digitising transport with data exchange and connecting people and vehicles for multimodality and seamless transport.

In this field we can see a fast, complex and far-reaching development, where we are now at a crossroads, with either the car industry and private sector occupying this field, or an integration of all players and possibilities by modelling new ITS scenarios. Under the "*Active Mobility first!*" precondition, ***Fusion Mobility*** is suggested as the frame when integrated and connected means of transport will functioning as mobility ecosystem for people.

It is important that these fast emerging new technologies that are data and AI driven, with big data operations for optimised services is orientated towards the idea of putting people first, not vehicles. We therefore need an informed debate about how we include cyclists and pedestrians within the connected ITS network. It is essential that we look for the threats and opportunities for AM that this entails.

In particular with the move towards self-driving vehicles this must be taken seriously as a great challenge and as a great opportunity as well. When car ownership is reduced significantly, people are able to becoming more flexible, and in well-structured and developed mobility systems even more independent, from the car, the high car costs, and also not being stuck in traffic congestions. It is *Connected Mobility* that can contribute to boost this freedom (more on this in section 5.4). Importantly we also have to stress data security and safety for people and for systems.[72]

Most important seems to be to widen the frame in AI development for sustainable mobility, as explained in 5.1.

TakeAway 6 – *Connected Mobility*

An intermodal eco-system as a well-connected mix of all modes of transport with best sustainable results is being developed, *Connected Mobility* works well when embedded in FM and unlocking its leveraging effect for all the other key-elements (building blocks). Furthermore it is becoming valid to work for people due to the binding effect for all the six key-elements.

5. *Fusion Mobility* Perspectives

Fusion Mobility is a great opportunity as it brings a change of perspective for researchers and practitioners: from technology centred to people centred, from disaggregated fields in transport and urban development to social-inclusive urban and regional systems.

Let us therefore stress *accessibility* as a criterion for people centred achievements with these questions:

- Is the technical improvement of vehicles and transport solutions bettering transport accessibility for all people? Or is it increasing class dominated hierarchies?
- Do we understand that increased energy consumption with additional technical solutions can also hurt accessibility for all?
- Are we aware that electrification of a non-sustainable transport system does not better the system significantly, nor does it automatically give more people better access?

There are many more questions like these, but bearing in mind how FM works, we know:

- That FM is essential to avoid systemic mistakes;
- That we should ask all these questions to test and to improve FM;
- That all transport solutions can get a fair chance in FM systems – let's call it competition for sustainable transport.

In all future fields of FM that implies that we will not only have great opportunities to create more sustainable transport systems – socially, economically, environmentally – but that for further FM development we will have a lot to do. Thus let us look at these investments and perspectives of our future, and let us ask the most basic question of any system:

What makes the *Fusion Mobility* system work?

To ensure systemic interactions these three conditions must be met:

- We have to respect and take into account the impact of the *corresponding axles* (see Fig. 3);
- We have to correlate all the Building Blocks (find the impact explained in 5.1);
- We have to measure the status of development of the Building Blocks on comparable scales (see 5.3).

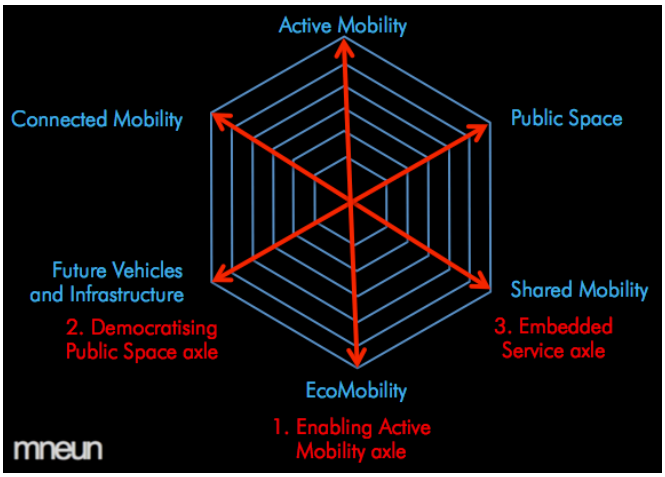


Fig. 3. *The corresponding axles* of *Fusion Mobility in bilateral systemic interaction of the six building blocks*

The impact of the corresponding axels can be described as follows:

1. AM and the EcoMobility hierarchy are the two poles of the 'Enabling Active Mobility' axle – basic for FM.
2. Where people and people in vehicles meet – supported by infrastructure, marks the 'Democratising Public

Space' axle – this is quite often an area of conflict, but that is exactly were livability comes from.

3. The future of mobility will be dominated by service systems; therefore the 'Embedded Service' axle is so important.

5.1. The systemic context for research

To better explain the systemic interaction of the six building blocks of FM, we can use a radar plot diagram for a first visualisation:

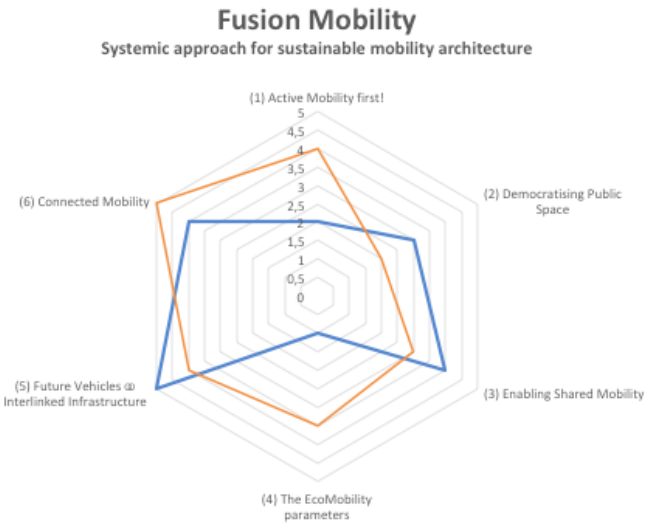


Fig. 4. *Fusion Mobility in systemic interaction of the six building blocks – Radar plot diagram with fictitious data*

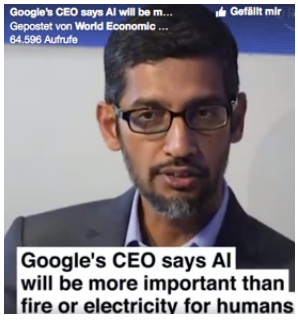
The radar plot is showing a fictitious example of two situations (two cities, before-after, etc.). From this example we can show two important aspects of Fusion Mobility that are challenges and opportunities at the same time:

- The six building blocks [BB-1 … BB-6] are not automatically interconnecting, they must be set into an interacting context, which will be not only bilaterally one-by-one, but can be even more diverse by each-with-all of the others.
- To compare different situations in urban and transport development, or also just to identify one, we must be able to measure each of them, and a comparable scale for all the six must be developed.

Let us pick out two cases of highest attractiveness due to its current importance for science and society about Artificial Intelligence (AI).

On highest levels of debate we can follow two very contrasting positions:

- Google's CEO Pichai Sundararajan said "AI will be more important than fire or electricity for humans, …"
- While Professor Stephan Hawking (†) and Tesla's CEO Elon Musk have both warned "that AI could end mankind".[73]



We know that AI is already work in progress, and it's being already part in *Connected Mobility*; with two 'IF'-cases:

(1) If AI will be isolated in *Connected Mobility*, the self-generating parameters will optimise just the dominant transport system(s);

(2) If AI will be not isolated in *Connected Mobility*, but also taking in parameters from all the other BBs in permanent systemic interaction, we will respect human needs and prioritize men before machines.

This case you can see demonstrated here – visualised in Fig. 5. – with the example of *Connected Mobility* [BB-6] in idealistic interaction with all other Building Blocks.

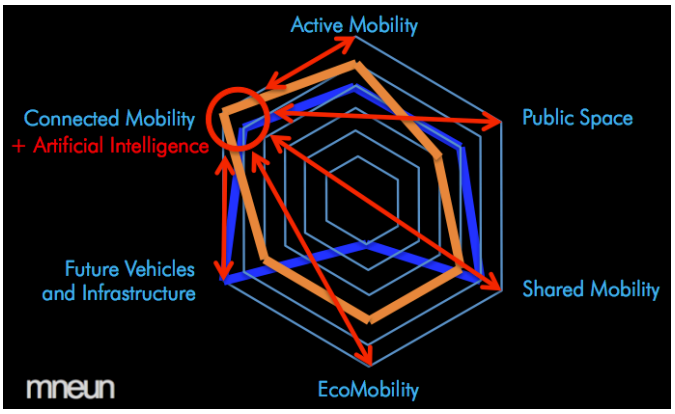


Fig. 5. *Bilateral systemic interaction of all six building blocks – the wider framing Artificial Intelligence effects*

The advantage for the development of AI is now clear:

Only when facing all the other elements in permanent systemic interaction, *Connected Mobility* with the support of AI will generate parameters optimised for the entire mobility system, people centred – not technology centred.

5.2. The systemic context for ITS development

The challenges for further development of Fusion Mobility are based on its strengths: the integrated approach for a systemic mobility concept. This means further collaborations on interdisciplinary research.

It should be pointed out this is not starting from zero. From TDM and TOD research it is known that there are numerous capacity building capabilities when unleashing the full potential of active modes.[74] From energy scenarios we know that saving energy can be the most effective role in future energy use. And taking into account the additional benefits of Active Mobility as mentioned above, with health benefits as the number one, this is indispensible for the increasing problems of our sedentary society.[75]

The systemic mobility concept with the six elements has a huge additional benefit for road safety. As stated by Soames Jobs, the World Bank's Global Road Safety Lead, a renewed systemic approach is necessary to overcome the current unsafe, car centred system.[76] And also the intentions here are not limited to transport only:

"Road safety goes beyond the transport sector, with a direct impact on public health, societies, and economies. Likewise, because road safety is an inherently cross-sectoral issue, real progress can only happen if all relevant stakeholders unite their efforts".[77]

As active modes will play an essential role, an overview on cycling related research delivers the numerous disciplines to be addressed and invited.[78]

Very practically, for ITS development we are not starting from zero: There have already been shown to be benefits in various ways from tracking travel movements in the European TRACE project[79]. For example: "… automated tracking may increase the efficiency of a behaviour change campaign: by registering travel movements without laborious input from target individuals or manual counting procedures, one can efficiently reward sustainable travel behaviour or efficiently measure the effect of particular behaviour change messages." This brings active modes to the same level with tracking well practised already for motorized modes.

Based on that, it is even more important that tracking is a key-influencer for urban and mobility planners. Therefore it is so important to collect data for urban mobility planning as from the active side. "Urban planners may learn about the type of roads and routes that are preferred by cyclists and walkers, and identify the bottlenecks that cyclists and walkers encounter, providing them with input for walk and bicycle plans. By further optimising the environment for cycling and walking, these sustainable modes of transport are likely to increase".[80]

This development is not only an excellent opportunity for ITS development as drafted above, it can be a support for global achievements such as the entire World Bank's "Sustainable Mobility for All" efforts[81]. Over all, future transport and sustainable development in general will be supported, when ITS implements *Fusion Mobility*.

5.3. For future audits: an assessment tool and good for indicators.

Practically we can imagine the future role of implemented *FM* delivering an assessment tool that

- Guaranties the holistic *FM* concept approach avoiding the negative effects of the common disaggregated development of the building blocks;
- Helps identify weaknesses and strengths of cities' and regions' development with promising effects for seamless transport and improved sustainable qualities;
- Will provide a systemic analysis for understanding further investments and integrated developments.

Based on what was already shown as a visualisation of FM, we can use a radar plot diagram now to create a tool:

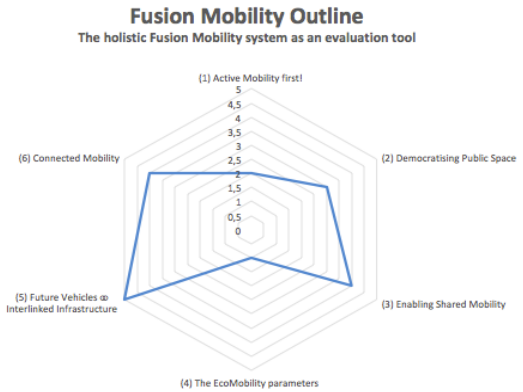


Fig. 6. *Fusion Mobility Outline – Radar plot diagram analysing a specific situation in a city or region*

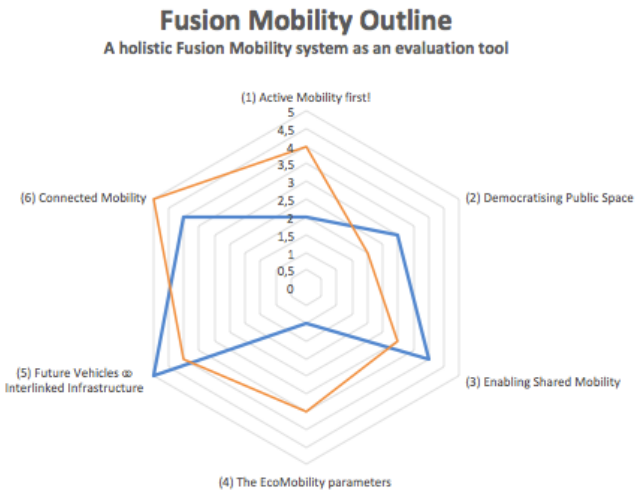


Fig. 7. *Fusion Mobility Outline – Radar plot diagram analysing two different situations to be compared*

Based on that: what are the perspectives of a *Fusion Mobility Outline* – the new FMO tool?

Firstly, this approach delivers orientation as a guideline in a segregated world of transport, in politics as well as in research. Only with a holistic approach, and *FM* is still a work in progress, we are enabling sustainable development. The main reason comes not only from the long list of benefits of Active Mobility, it comes from the systemic approach. We will not achieve in making non-sustainable systems sustainable by reducing non-sustainable measures. Sustainable modes must be built up as part of a sustainable ecosystem.

Secondly, the sustainability potentials of the FM elements (Building Blocks) will under sustainability criteria work better in systemic interaction than standing alone (see 5.1). For several of the interactions of the FM elements this is obvious, but also evident as we can observe in fast emerging fields as in Shared or Connected Mobility.

Thirdly it will require input from many sides to develop and to improve it. For collaborations of researchers from the ITS and AM world this delivers the outstanding opportunity to be at the head of the exciting future world of transport and people centred mobility. Thereby also a step forward in "New mobility policies: from transport departments to mobility networks" will be supported significantly.[82]

There are several indicators and indices existing for measuring and expressing qualities and quality improvement of cities or countries according to criteria like quality of life, liveability and walkability/bikability.[83]

As we can see, the focus of Fusion Mobility is different, and at the same time delivering a wider frame on sustainable mobility and urban design development – this also then provides an excellent opportunity to use the approach also to invest in an indicator.

5.4. Fusion Mobility benefits for decision makers

The quality of decision making can best be seen in investments, when on a long term – after one or two decades

– people will appreciate the improved quality of their cities, even when they will not always remember that it was based on long-term wise decisions of their city councillors long time ago. Anecdotally and what we can see in reality, these good examples seem to be rare. And for sure this kind of decision making is not easy. As a proposal for sustainable development, FM must significantly help to improve and inform these decisions.

Also as an example, FM and FMO together have the systemic potential to improve road safety and health by increasing the EcoMobility modes. We are not able to overcome the current unsafe transport system, we have to build a safe system from the bottom up – as mentioned above as this is current state of the play in research and global debates.[84]

Concluding the *Fusion Mobility* perspectives and the FMO tools proposed benefits, though they are not known for large structureal changes, there is a promising perspective for future ITS applications: Governments and public administrations.[85] But a transparent tool such as FMO could be accepted and adopted by them, in particular when presented as a state of the art tool.

6. Conclusions

The strengths of *Fusion Mobility* lies in the integrated approach for a systemic mobility concept. All means of transportation are represented, while human needs and rights are prioritized.

For *Connected Mobility* the specific challenges and opportunities of *Artificial Intelligence* were discussed. This example stands most prominent for all future preconditions and options that *Fusion Mobility (FM)* offers for guiding principles for a new world. With FM sustainably comfortable, healthy and more affordable – what a great perspective. The merger of ITS and Active Mobility development in the FM concept will have value generating effects, in particular for 'Sustainable Mobility for All'.

Thus, the *Fusion Mobility* approach is offering a promising perspective for a sustainable and human friendly future in urban and transport development and beyond.

7. Acknowledgements

Writing about *Fusion Mobility* let me express my gratitude to Professor Jason Chang from the National Taiwan University for setting the term *Fusion Mobility*, for inviting me to take on the subject, and taking the risk that I make something from it.

Being invited to introduce *Fusion Mobility* at the TDM symposium in Taipei and for intense and fruitful discussions, I would like to thank and acknowledge in particular the chairing professors Wafaa Saleh, Edinburgh, and C.H. Louis Wei, Tainan – who stimulated me to invest in the development of a Fusion Mobility Outline approach introduced with this paper.

The risk for the concept and the *"Active Mobility first!"* thesis and consequences are all mine, but I would like to take the opportunity to thank some of my friends who have helped develop the Active Mobility paradigm. Thus I would like to acknowledge the collaborative work of Eric Britton, Jason Chang, Peter Cox, Martin Held, Todd Litman, John Parkin and Jörg Schindler.

I would also like to mention that this all happened embedded into the collaborations of the global ECF network "Scientists-for-Cycling", and in particular with the S4C advisory board.

8. Publication Remarks and Citation

This comprehensive draft paper is explaining *Fusion Mobility* with the focus on social implications, as requested for Velo-city 2018 Rio de Janeiro according to the motto "Access to Life". In particular it was to stimulate the discussions in the Scientists for Cycling sessions at Velo-city 2018 Rio.

There was a second paper written submitted and accepted to the ITS World Congress 2018 Copenhagen. This paper is focusing more on the technical oriented aspects of ITS methodologies and related.[86]

For this paper here please use the following citation:
Neun, M. 2018. "Fusion Mobility – Discovering the Mobility-DNA of Inclusive Cities". Paper delivered to Velo-city 2018, Rio de Janeiro.

9. Glossary

9.1. About the Author

Manfred Neun was president of the ECF (European Cyclists' Federation) for 12+ years, and President of WCA (World Cycling Alliance) for 4 years; he was chairing the global network Scientists-for-Cycling (S4C) for 8 years, and he is still a member of the S4C advisory board. At this year's AGM in Milan he was awarded an "ECF Honorary President".

Neun is acknowledged a global advisor in integrated and sustainable urban and transport planning. His focus is on content development for cycling and active modes, and he is known for his paradigms, new terms and approaches. In particular he worked with colleagues to introduce Active Mobility and the Active Mobility Agenda (since 2008), and he introduced 'Cycling Economics' as a macro-economic approach to research and sustainable development (since 2011). With these approaches he was highlighting the socio-economic benefits of cycling and Active Mobility in general, and in particular to the UN Sustainable Development Goals.

The *Fusion Mobility* approach (since 2017), introduced also with this paper, is a consequent step forward in his systemic thinking for integrated and connected mobility, drafting sustainable development corridors for urban and transport planning.

9.2. Glossary with Terms and Abbreviations

Table 3 [87] [88][89]

Table 3 GLOSSARY with Abbreviations and Definitions

Terms, paradigms	Abbr.	Definitions
Active Mobility	AM	AM is a form of transport of people or goods that only uses the physical activity of the human being for the locomotion. It's mostly walking and cycling in all its forms, but also wheeling by skates, skateboard, push scooters or wheelchairs. AM is intended to be an overall positive mental framing in contrast to NMT and to overcome its limitations.
Active Mobility Agenda	AMA	Based on the AM paradigm, the Active Mobility Agenda (AMA) was started as agenda setting for cycling and AM benefits. All these benefits were framed as an (matrix) overview by nine key-issues as there are as *basic factors* (1) Environment and Climate, (2) Economy, (3) Social Affairs; as *boosting factors* (4) Energy and Resources, (5) Technology and Design, (6) Mobility; and as *balancing factors* (7) Health, (8) Time and Space, and (9) Diversity of Cultures. AMA is intended to stimulate interdisciplinary research and collaborations, and has already proved to evaluate the annual socio-economic benefits of cycling or to how many of the UN Sustainable Development Goals (SDGs) cycling contributes to.
Fusion Mobility	FM	*Fusion Mobility* is an Active Mobility based concept for future multimodality. It is a people centred overarching approach that takes the strengths of ITS methodologies and merges them with parallel developments in Active Mobility and Sustainable Development to ensure further improvement of seamless transport, and that ITS systems make a maximum contribution to "Quality of Life."
Intelligent Transport Solutions	ITS	ITS integrate telecommunications, electronics and information technologies with transport engineering in order to plan, design, operate, maintain and manage transport systems. ITS are advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and 'smarter' use of transport networks. [78]
Cooperative Intelligent Transport Systems	C-ITS	C-ITS enables digital connectivity between vehicles and between vehicles and transport infrastructure, and is intended to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation. [79]
Mobility as a System	MaaS	Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand. [59]
Motorized Individual Transport	–	Motorized Individual Transport includes any form of transportation that provides personal or goods mobility by individual vehicles driven by combustion motors. Currently the quantitative leading category inside Passive Mobility.
Non Motorized Transport	NMT	NMT includes any form of transportation that provides personal or goods mobility by methods other than the combustion motor. Walking is the most familiar form of NMT; followed by bicycles/tricycles; human porterage; handcarts/wheelbarrows; animal drawn carts; and other small-wheeled transport (skates, skateboards, push scooters) and wheelchair travel.
Passive Mobility	PM	PM is a form of transport of people or goods that uses energy driven vehicles for the locomotion. It's mostly motorized individual transport and Public Transport.
Pedelecs	–	Pedelecs (Pedal Electric Assisted Cycles) or EPACS (Electronic Power Assisted Cycles) are recognized as bicycles however when pedalling the rider gets progressive assistance from the electric drive system. The most popular and highest selling pedelec is the sub 250 watt pedelec/ sub 25 kmh bike that needs no type approval like motorised vehicles and is regulated through CEN standard. [65]
Public Transport	PT	PT is a shared passenger-transport service available for everybody. PT modes include buses, trains, trams or light rails, rapid transit (metro, MRT, BRT, underground etc.). Also Public Bike Schemes are part of PT.

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