23rd ITS World Congress, Melbourne, Australia, 10–14 October 2016

Paper number ITS- AN-TP0657

Soft Vehicles, Soft Roads, Soft Transport

Shift from parallel to a coherent perspective

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Abstract

Automated vehicles are part of a broader picture where the trade-offs between hardware, software and human interaction are blurred and it becomes much more difficult to distinguish between infrastructure, vehicle and person. We have chosen to express this as soft vehicles, soft infrastructure and soft transport. Governance will be increasingly be affected by these three interactions. Examples of this interaction is considered. Transferring control from the active driver to a mix of vehicle and infrastructure is under way. Autonomous vehicles are clearly simply the first step; and one that already creates problems for risk management. This might best be expressed in terms of Mobility Not Transport: and Activities and Services not just Movement. Concrete examples are the impending collision of increasing monitoring of road systems by sensors feeding traffic control applied to direct road movement management signals (soft roads), and the growth in autonomous vehicles reliant on GPS and sensors and massive processing becoming more dependent on a mix of software and communications. Overlaps and mergers of these and other aspects are inevitable, moving towards flexible sharing of the responsibilities for sensing, control and action. Consideration of autonomous vehicles need to travel under 'their' own steam in remote areas is important with potential reliance on a system like Galileo/Egnos and the communications and control available from the safety of life parameters of this system. Greater recognition and responsiveness by government is now clearly critical to decrease harm to the traveling public, increase transport efficiency and resilience of our transport networks.

Keywords:

Automated Vehicles, Infrastructure, Mobility, Governance

Introduction

Evidenced based scientific research, engineering development and project management requires disaggregation of a problem and a quest for evidence based decision making. Good public and transport policy development should be developed in the same way. This paper considers mobility and accessibility in Australian society in a uniquely broad manner, at a time when significant disruptive forces are apparent. The main disruptive[1] force of Automated Vehicles (AV) is when considered as a broader picture where the trade-offs between hardware, software and human interaction are blurred. It then becomes much more difficult to distinguish between infrastructure, vehicles and people overlapping with services. We have chosen to express this change as soft vehicles, soft roads and soft transport.

This paper has been inspired in part by recent discussion held between the authors regarding the scope of the Austroads brief to review the impacts of automated vehicles. The highly disruptive nature of automated vehicles offers a timely opportunity to reflect on accessibility, mobility, transport and urban planning for our future.

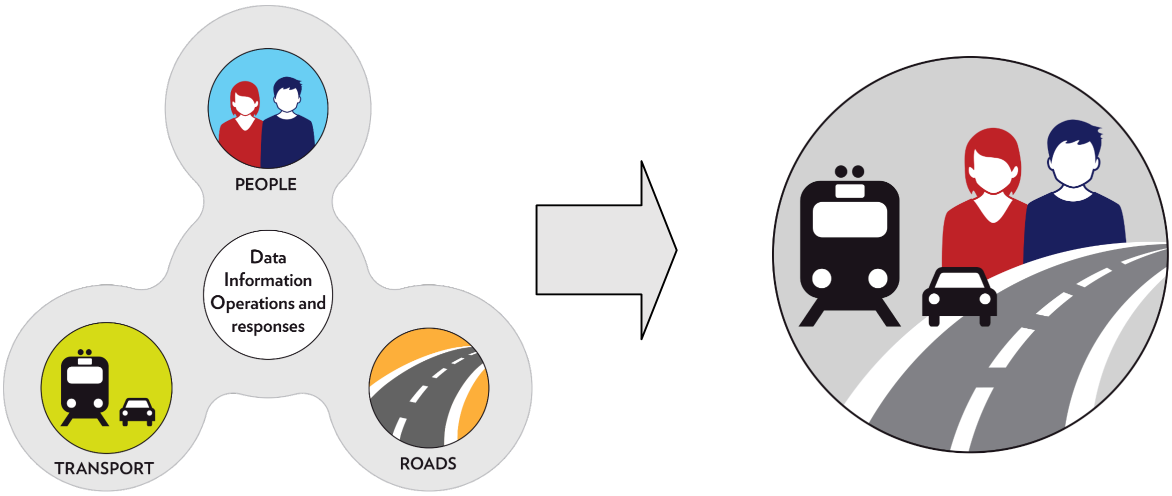

Figure 1: Soft Transport: Shift from parallel to a coherent perspective.

This paper will consider the following elements which will shape our view of the future

- Our needs for access
- Demographics of people
- Demographics and nature of existing vehicles now and in the future
- Potential vehicle and mobility response
- Required policy, strategy
- Key technology requirements, particularly from a road operator perspective
- Involvement of public and public relations
- Human resource development required to move forward better understanding and development of key skills to realise these outcomes

Need for Movement in an Increasingly Urban and aging Society

There is always need for good data to understand demography of our population, demography of vehicles, traffic movements and the need for travel. This is especially the case in Australian cities experiencing significant growth and substantial densification.

Transport planning techniques have broadened considerably in recent years to consider the many influential factors, however it is well recognised that predicting our future 30 years in advance is non-trivial. We have chosen to consider three of the major themes at play:

1. Significant change in demography, and a very limited understanding of the needs of an aging population.
2. Increased urbanisation and movement towards a serviced based economy
3. Rapid advancement in technology, in particular the internet of things (iot) and more recently automated vehicles potentially viewed as a subset of iot which are likely to have significant impact on our travel in the future.

The key change in demography of the population of Australia is well documented, an aging population with people aged over 65 estimating to be increasing from 14% in 2012 to between 22.4% and 24.5% by 2061. The aging baby boomer population will be most dramatic and requires careful consideration in transport and other policy. Contrast this with our current view of transport related population demography. We generally have one data category (65+), which provides very little insight to a group aged between 65 and 105. We have very little data about this growing demographic to inform decision makers about their needs or wants. It is likely to be a demographic that is much more educated, affluent and technology savvy than previous generations.

There are many factors that need to be considered for the aging population:

1. Capturing their opinion across a range of public policy areas including transport. Sine qua non, or "without which [there is] nothing" is a maxim often adopted by disabled groups that could adequately describe the needs of the aging population to have a voice in policy development
2. Particular issues regarding eyesight, hearing, cognitive impairment and personal mobility which are generally assumed to always be degenerative, but this will not always be so with advances in medical technology and treatments
3. Transport mode preference and accessibility of these modes

For example: Increased mobility and access may define an aging society by way of freedoms, human rights, voice and livability. Similar to other marginalised and disabled groups in the past disruptive technologies may expand transport options available to the aging and other groups who have restricted mobility choices .i.e. dependent on others for transport services,

Our knowledge of the need for travel and the level of occupancy in vehicles is relatively limited in Australian cities. In Victoria the VISTA travel survey in Victoria represents a very small proportion of annual trips[2] with approximately 6,000 out of 2,000,000 households surveyed in 2013. We know that these surveys can offer reasonable comparison to reality in peaks but can be very data poor and have difficulty in describing commercial traffic. Even our understanding of vehicle occupancy, a key Austroads Indicator and factor in determining transport efficiency is very limited. This is still determined by visual surveys undertaken on the side of a freeway with traffic traveling at 80kph through tinted windows or bus windows covered with advertising. The inconsistency between reporting methods i.e. Austroads e.g. sampling of selected urban arterial roads and freeways versus the Australian Bureau of Statistics (ABS) using questionnaires survey of all road use including local and collector roads and method used by Bureau of Infrastructure Transport and Regional Economics (BITRE) as well as different interpretations and selective use of statistics lead many transport practitioners to considerable miss-understanding on road use in Australia. Technology offers significant opportunity to understand the movement of vehicles and people in a very detailed way, however surveillance, privacy and ethics needs to be considered and is discussed further under surveillance and ethics below.

Transport, Accessibility, Mobility

Transport accessibility is considered a key factor in determining the efficiency and productivity of our cities. Economic benefits based on a basic consideration of accessibility do not consider many of the broader societal and sustainability benefits of more sustainable modes. Cycling and walking have significant health benefits. Some research suggests that are potentially significant social equity benefits for the promotion of active transport over other organised sports and recreation activities[3] these are element that can add to the unique quality and form of a city. We need to consider accessibility and mobility through different lenses. Planning our cities transport using traditional mode based strategies or approaches loses the opportunities to better understand and meet the needs of our citizens who need to be considered in terms of terms of ***Mobility*** not transport: and ***Activities*** not just movement.

Transport planning in Australian has been too simplistic and focused heavily on mode specific development over recent years. Major transport infrastructure development has become highly politicised and polarised into a road versus rail discussion. A new dynamic has been apparent in Europe over recent years, and recently coined as mobility as a service or mobility on demand (MOD). MOD is completely user centric and could involve any mix of modes and services to deliver the best possible outcome for an individual. With EU projects such as EMPOWER[4] which are designed to promote sustainable mobility models there is real potential for many EU cities to achieve a step change to more sustainable transport modes. MOD has been enabled by technology (mainly vehicle tracking, booking and smart phone applications) and is highly disruptive cutting across many modes of transport. Government response to the Uber car sharing has been viewed as a complete policy failure in many jurisdictions as customer move to what they perceive as a better value service. MOD and automated vehicles are often mentioned in the same sentence, with bold predictions that MOD will result in significant increases in vehicle occupancy and as a result decrease traffic levels on our roads. It is important to note that:

- Any significant shift towards ride sharing services will result in a very different use of kerbside space (discussed further below)
- The amount of sharing will depend on cost and availability of alternatives, public acceptance

and any government response to help or hinder and this is likely to have a significant impact on some public transport services.

The blur between public transport and private transport has been brought to a head with Uber. There may be no need for taxis to be a public service in the way it was conceived 100 years ago and Public Transport may head the same way with MOD and the ability for small cars or “carriages’ to link up to become trains. One such concept being Tommaso Gecchelin and Emmanuele Spera’s vision of a Swarm vehicle outlined in Figure 2 below[5]

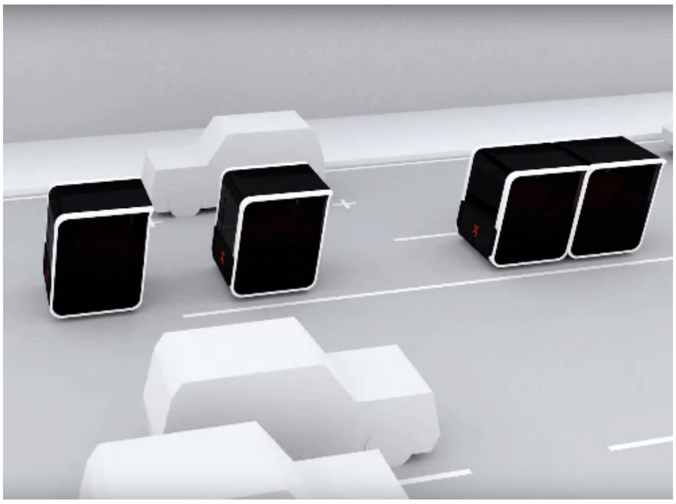

Figure 2: Tommaso Gecchelin and Emmanuele Spera’s Vision for Swarm Vehicles

One of the more telling indications about the potential disruptive implication of MOD is the insurance industry response. At a recent insurance conference Valter Trevisani, Group Head of Insurance and Reinsurance, Generali presented on the wide scale technology impacts for the insurance industry. They are seeking to introduce new premium models that will more accurately consider individuals driving habits, moving away from consideration of insuring a vehicle and instead focusing on the driver[6]. This also has important implications for the consideration of surveillance and data sharing and management to be discussed in more detail below. The insurance industry may seek mandatory data sharing from individuals using shared vehicles to ensure their insurance coverage. Use high levels of automation in these vehicles is likely to be seen as highly favourable, and being encouraged by offering lower premiums for using these functions.

The brief points above should illustrate the disruptive nature of MOD and the need for significant consideration as part of wide ranging transport policy review across all levels of Australian Government. We look forward to seeing the updated Commonwealth Government ITS policy framework at the time of writing this paper. We should closely track the development of MOD in the EU and elsewhere and seek to test the transferability of these learnings in Australian cities ASAP.

The above considerations have substantial implications for health, community vitality, transport, infrastructure and technology strategy. This will be discussed in some detail in the final section of this paper (Human Resource Management).

Consideration of Technology and Soft Roads

System engineering principals are becoming more widely accepted as a base to consider technology deployment in Australia. One example is the increasing prevalence of use of the development of a concept of operation for technology implementation. This was a central part of the recently developed Framework for deployment of Managed Motorways[7]. It is of key importance to consider the user needs and the concept of operation before the core technologies requirements can be considered. Down at the next level of detail our understanding of the physics of traffic engineering is still evolving. This has been based on the concepts of stochastic cellular automata or 'probabilistic cellular automata (PCA) [8]. The capacity of roads is highly linked to:

- Internal friction within the carriageway where we see lane changing exacerbated by increasingly shorter trip lengths and
- Friction at nodes where we intersections and pedestrians, cyclists, public transport priority.

We can generically consider two levels of technology needed for a wide range of ITS:

1. Information – monitoring information about the movement of people and vehicles and provision of information to individuals on smartphone or at the roadside / trackside or information from users or vehicles used to inform safety critical systems
2. Control: control of people or vehicle movements and the exchange of safety critical information to allow automated control.

Different user needs for technology will have very different technology requirements. For example: information about an upcoming planned roadworks event should be treated in very different way to a safety critical piece of information relating to deployment of an airbag indicating a potentially life threatening incident has occurred. The framework of a technology response and associated standards needs to consider these priorities in a structured manner. We first need to understand where greatest benefit would result (saving life) and ensure that these priorities are supported with the deployment of appropriate technology through evidence based research. Information concerning mobility will have a lower priority but is still needs to be considered in a similar and structured manner.

A key focus for technology application should be rural environments, where automated vehicles are essentially required to operate "off their own steam" far away from highly equipped infrastructure available in metropolitan areas. Approximately half of the road crash fatalities in Victoria are in rural environments. Over time there has been significant effort spent in focusing on the causal factors (such as drink or drug driving and speed) by VicRoads, the Victorian Police, the TAC and a range of research organisations. Consideration of how quickly we respond to incidents is extremely important in the short term. The availability of an eCall system has been noted to provide substantial benefits in other jurisdictions and has now been mandated[9] eCall is a key technology which could be considered to reduce harm and fatalities in Australia. The remoteness from appropriate road trauma treatment compounds the need for swift emergency response in rural environments, The data on non-declared roads in Australia, those under LGA administration, is still very weak. This has in the past been uneconomic to correct, but with cheap IoT style active infrastructure sensors- not only on bridges- correcting this is within our grasp. As the agricultural sector is of prime importance in many rural areas and the road damage substantial, the expended use of smart roads in rural areas is and under appreciated direction now becoming practical. The sue of combined soft roads (instrumented autonomously) and soft vehicles(managed largely by software_) offer real gains in the economics of rural roads.

There are three major technology topics which have significant bearing on transport in Australia at present:

1. the internet of things (iot).
2. automated vehicles (AV) which can be viewed as a subset of the wider iot umbrella
3. the proliferation and use of smart phone mobile applications (apps).

The need for smart phone apps are well understood by the wider IT and ICT industry and are being well catered for at present. In addition there is strong customer thirst for targeted information to assist with daily travel. Iot and AV have some very specific needs, a key common need is a highly reliable, robust communications networks with substantial bandwidth (with IPV6 addressing). This is an issue that is currently be considered in detail in Australia and elsewhere, the need for Connected and Automated Vehicles (CAV) is being widely discussed. The form of wireless communication is still being considered with 5G on the near horizon. There is a need for a high bandwidth backbone to deal with the data from iot (very high volume) and ITS (generally very small in comparison to the potential volume of iot with the exception of video images), terrestrial fibre is currently the only way to cope with these data backhaul requirements.

AV have a strong need for highly accurate positioning. There are a number of different proposals and models to deal with these issues. Other counties satellite arrays could be considered to be used in conjunction with our existing positioning arrays. The application of the European Geostationary Navigation Overlay Service (EGNOS) in Australia with the addition of another satellite in this region which could supply us with the positioning accuracy required for AV and the safety of life operational standards that are part of the EGNOS Galilieo system and provide much needed coverage for other safety critical systems mentioned above such as eCall.

Considering the levels of redundancy for safety critical systems is vital and will require a robust systems engineering approach to ensure that decisions are being made in a highly transparent manner.

Development of iot in road environment provides an unprecedented opportunity to deploy sensors and control systems in a very cost effective manner on the roadside but just as importantly as part of vehicles and smartphone functionality, allowing a highly flexible way of managing the road environment: the beginning of “softroads”.

Needs and Design of Soft Vehicles

The introduction of MOD, automated vehicles and significant development of battery technologies has begun the age of soft vehicles. The update of the Tesla S software release 7 late in 2014, is perhaps the best example of the update to vehicle function "over the air" to date. The Tesla already had a suite of sensors to allow lane monitoring and other related features. The new software release downloaded by users overnight allowed the vehicle to function in a more highly automated manner. This sort of disruption has been widely discussed and it brings the consideration of regulation into sharp focus. It is currently being discussed and considered by the National Transport Commission here in Australia and similar organisations internationally. The Tesla S was imported with one set of functions, and overnight it has another. Our technical abilities to change the function of the hardware (the vehicles) have outstripped our ability to manage this system have overtaken regulation, and the beginning of the age of the "soft car" with some of the characteristics previously only seen in human drivers now apparent. We see a shift to a performance basis to "licence" a vehicle in a similar way we consider human drivers as one possible outcome.

We have been witnessing an increase in the use of powered two wheelers (PTW) in the UK and Australia and other jurisdictions in recently years[10]. The push of compact vehicles in highly congested environments has again led to some blurring around the definition of cars and PTWs. Electrification if expected to increase this take up and we are expecting low powered electric motorcycles or potentially high powered electric bicycles (depending on the perspective – or rather the legal definition - taken) to become far more prevalent.

The interesting development is a rising demand for the driver to become another connected component, This is best explained by the rising demand for Bluetooth 4.0 communications which are vehicle and road environment interactive e.g. communications in motorcycle riders helmets. This positions the vehicle the driver/rider and the road all as smart interactive data stream, with interaction a critical factor. No one domain will have primacy in this developing model.

One and two person vehicles or pods are likely to become the main transport paradigm in urban and suburban areas, allowing us to considerably increase utility from the road network i.e. small vehicles are best and large vehicles could be viewed as unsustainable dinosaurs. This could apply to public or shared transport with trams and large buses becoming obsolete due to lack of flexibility. When transport is broken down into its basic function of movement from origin to destination of people and goods and time. New disruptive paradigms for transport emerge. i.e. small and flexible, verses large and inflexible, vehicle size appropriate to activity/economic rather than one size fits all, diversity rather than conformity (mobility has many modes).

Our understanding of the "soft vehicle" could include cars and other vehicles such PTW or bicycles could have their performance monitored or controlled through software and interaction with the roadside, rather than complete reliance on the driver. This could be seen as analogous to the limitation of AV mode being dependant on the location of the vehicle. This again challenges the current consideration of regulation and blurs the boundary between infrastructure and vehicle. We need to consider the regulation of vehicle performance (and function) based on location, speed, weather and potentially other factors. Road operators will have a significant role to play in these considerations and the potential "certification" of roads or the counter approach (what roads are not appropriate) for use by certain vehicles in particular scenarios.

Surveillance, Privacy and Ethics

As mentioned above, new technologies provide new functions with substantial benefits to the road operators, government and most importantly the community. It is important that the risks with the potential introductions of certain technologies, and protocols is understood and transparently discussed before moving forward with any given technology. This is something that needs to be carefully considered by governments who ultimately control large databases of personal information. However there are also significant implications for the private sector. Privacy principals and the concept of "privacy by design". The two approaches possible to address such issues at the root are still not part of State of National Policy or recommendations for Good Practice. These are twofold

1. "Wigans Law" [11] [12] "Any ICT system that is seen to have a potential for privacy or surveillance capacities must be auditable to demonstrate its incapacity to do so"
2. The later re-expression by Ann Cavourkian in Canada as "privacy by design" [13], now widely understood as Good Practice and encompasses business processes more widely.

While there are of course a number of others, these suffice to clarify some of the key aspects that need to be considered.

Human Resources Management

The disruptive nature of the changes to our transport system and society requires a significant interaction between disciplines. The regulatory, policy, technical and ethical dimensions discussed in this paper require consideration across a wide range of industries, many of which may in the past have had little need to interact. The human resources management to ensure that these interactions can occur in a highly effective manner and achieve the outcome we require is a highly complex task. Open, transparent communication is key. Education in the workplace to improve cross speciality understanding is essential, while universities need to add this to at least their doctoral education process. This has been successfully trialled by the Melbourne sustainable society institute (MSSI) with the mentoring involvement by one of the authors (Marcus Wigan).

Conclusion

This paper considers a range of disruptive trends most notably: electrification, automated and mobility on demand which are having great impact and offer significant potential to improve the way we develop and operate our roads and transport networks. These factors will significantly impact on personal mobility and livability of our cities.

We have presented a wide range of practical development three key domains to consider the disruption. All three domains are morphing and can be viewed as malleable: what we have described as "soft"

- Soft Vehicles
- Soft Roads:
- Soft Transport

There is a very strong interaction between the domains. A systems engineering approach is required to consider and manage these interactions to ensure the most effective outcomes. The range malleable nature of these domains means that we have a very limited time to develop policy and governance frameworks to manage the process. Failure to implement these frameworks in a timely and flexible manner means that we are currently unable to take advantage of new opportunities these data driven technologies Changing technologies offer significant opportunity for more effective engagement with the community on the range of issues. The need for an open, transparent approach to data management and exchange should be a key part of those discussions. Simple carefully crafted scenarios are needed to make this a reality for the community to achieve the ultimate goal of prosperous, sustainable and livable cities.

There is also a significant impetus for the ITS community to engage more openly with a wider range of professionals across the three domains described to ensure our industry can evolve to meet the current and future challenges outlined in this paper.

References

1. Disruption is viewed as creative function where significant gains can be achieved http://www.investopedia.com/terms/c/creativedestruction.aspschumpter
2. http://economicdevelopment.vic.gov.au/__data/assets/pdf_file/0011/1269290/VISTA-2013-An-overview-of-travel-in-Victoria.PDF
3. https://chartingtransport.com/tag/car-occupancy/
4. https://chartingtransport.com/tag/car-occupancy/
5. http://sensibletransport.org.au/wp-content/uploads/2015/10/QLD-Health-Stage-1-Report-Full-10.09.11.compressed.pdf

6. http://empowerproject.eu/
7. http://www.next-future-mobility.com/#!analysis/mainPage
8. tu-auto.com/generali-telematics
9. https://www.vicroads.vic.gov.au/~/media/files/technicaldocumentchapters/guidelines/managed-motorways-framework-september-2015.pdf?la=en
10. http://www.pd.infn.it/~agarfa/didattica/met_comp/lab_20140108/1992_origca.pdf
11. http://europa.eu/rapid/press-release_IP-13-534_en.htm
12. http://stat.abs.gov.au/
13. http://www.rogerclarke.com/DV/
14. Daniel, M., Webber, M. J., & Wigan, M. R. (1990). Social impacts of new technologies for traffic management (ARR 184). Retrieved from Vermont, Victoria
15. Cavourkian, A (2011) Privacy by design: The 7 Foundational Principles at https://www.ipc.on.ca/images/resources/7foundationalprinciples.pdf

1 Disruption is viewed as creative function where significant gains can be achieved http://www.investopedia.com/terms/c/creativedestruction.aspschumpter

2 http://economicdevelopment.vic.gov.au/__data/assets/pdf_file/0011/1269290/VISTA-2013-An-overview-of-travel-in-Victoria.PDF

3 http://sensibletransport.org.au/wp-content/uploads/2015/10/QLD-Health-Stage-1-Report-Full-10.09.11.compressed.pdf

4 http://empowerproject.eu/

5 http://www.next-future-mobility.com/#!analysis/mainPage

6 tu-auto.com/generali-telematics

7 https://www.vicroads.vic.gov.au/~/media/files/technicaldocumentchapters/guidelines/managed-motorways-framework-september-2015.pdf?la=en

8 http://www.pd.infn.it/~agarfa/didattica/met_comp/lab_20140108/1992_origca.pdf

9 http://europa.eu/rapid/press-release_IP-13-534_en.htm

10 http://stat.abs.gov.au/

11 http://www.rogerclarke.com/DV/

12 Daniel, M., Webber, M. J., & Wigan, M. R. (1990). Social impacts of new technologies for traffic management (ARR 184). Retrieved from Vermont, Victoria

13 Cavourkian, A (2011) Privacy by design: The 7 Foundational Principles at *https://www.ipc.on.ca/images/resources/7foundationalprinciples.pdf*