Commission of Inquiry - Vision for Hampshire 2050

Evidence summary report

Mobility, connectivity and energy

25 January 2019

HAMPSHIRE 2050
VISION FOR THE FUTURE

Mobility, connectivity and energy

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1. Purpose

A short report to summarise the expert evidence received in relation to the Mobility, Connectivity and Energy theme to assist Commissioners consider, alongside the full evidence pack and theme hearing, the following three questions:

1. What do you think might happen in the future?
2. How will that effect/impact on what we do?
3. How will the County Council and Partners need to react in light of this?

2. Introduction

The Mobility, Connectivity and Energy theme considers how people will travel in the period to 2050, the way in which advances in information technology will affect how people live and work over this period, and the implications for energy of these changes. The future of mobility is intrinsically linked to the energy requirements of vehicles and the connectivity between vehicles and between vehicles and the roadside. The infrastructure needed to deliver the connectivity and energy associated with future mobility will impose new requirements on service providers, while ensuring the benefits are available to the whole community may need investment by public authorities where not commercially provided.

3. Theme scope

The assessment has considered potential changes in the way people may travel, live and work between now and 2050. Technological advances will fundamentally change what is achievable over this period, but Government policy will be key in establishing which innovations will be legislated for and the financial support available to stimulate adoption. Commercial decisions will also determine the extent and speed of change and will in turn be affected by consumer demand. Issues for Hampshire County Council and partner organisations are likely to include delivering policy outcomes and any associated statutory obligations, and also responding to potential equality issues affecting Hampshire communities where new technology may not be commercially viable.

Each of mobility, energy and connectivity could justify an individual theme within the Hampshire 2050 commission. The focus of this review has been the transport impact of electric powered and autonomous vehicles, the impact of smart technology in homes and workplaces, advances in communications technology and future energy issues.

4. Expert evidence

This report considers information published by a number of leading sources, including government advisors such as the Infrastructure Commission, and seeks to summarise the principal issues identified affecting mobility, connectivity and energy.

Internal discussions, workshops with external experts and stakeholder meetings have taken place, and the ideas raised through these forums are reflected in this document and the accompanying internal technical report[i].

A number of specific pieces of evidence on the future of mobility have also been provided by external experts including University of Southampton, SNC-Lavalin Atkins and the Local Government Association.

SNC Lavalin Atkins[ii] identify four themes determining future mobility:

- Urbanisation putting pressure on transport networks, with transport congestion and pollution leading to demand for infrastructure and new travel solutions.
- Climate change and sustainability, with issues such as resource depletion and poor air quality, and requiring a greater focus on resilience and regulatory and policy action to change behaviours.
- Demographics, where population growth, an increasing aging population, and changing habits of younger people, create specific mobility and equality issues.
- Technology, including personalisation, on-demand services, increasing penetration of smartphones, which result in innovative services and new business models. Technology is developing at an unprecedented pace. The transportation sector is experiencing a period of significant disruption, with new technologies, products and services fundamentally shifting customer expectations and opportunities

Social and economic trends are also starting to change behaviours. Younger people are increasingly more likely to hire or share a car rather than own one themselves, and new on-demand ridesharing services are appearing around the world.

Intelligent Mobility has emerged as a term encompassing a new technology enabled approach to connecting people, places and services. SNC Lavalin Atkins predict that Intelligent Mobility will transform the transport sector with an estimated global market of £900 billion by 2025.

SNC Lavalin Atkins identify the need for a long-term strategy to meet infrastructure and housing demands alongside needs of residents. This strategy will need to be integrated with other sectors (healthcare, land use planning etc.) and emerging technologies, with a need for a co-ordinated business operating model across multiple service activities to create connected ecosystem of transport, including private and public transport modes, and reflecting the growing sharing economy.

SNC Lavalin Atkins recommend that:

- A single vision be developed to bring together all sectors with a transport role to ensure that dependencies are understood and analysed.
- Ensure future transport projects reflect emerging technologies and business models such as Mobility as a Service.
- Establish collaboration with the neighbouring local authorities and wider Local Enterprise Partnership areas to maximise the impact of the investment in Intelligent Mobility.

The Local Government Association (LGA)[iii] see automation, connectivity, and electrification as three trends affecting future mobility, and identify a number of ways these will impact on services.

Providing for future connected and autonomous vehicles and emerging shared mobility options will require transport planners to rethink transport provision, and also provide new opportunities for public realm. Parking requirements in particular could radically change as shared, autonomous vehicles will not necessarily need central parking.

Network Management will also change as sensors become pervasive. Details of hazards, changing conditions and failing infrastructure could be communicated directly to vehicles, which could adjust their speed or route accordingly. The ability to access real-time information on traffic flows across an entire network also offer new possibilities to proactively manage networks. The knowledge of the location, speed and direction of all vehicles means that traffic disruption can be predicted ahead of time and mitigated through passing to connected vehicles information on other routes.

New sensors combined with big data analytics could also change asset management, replacing periodic inspections with continuously reported information on asset condition such that defects can be logged before catastrophic failure and the condition of the entire asset base can be assessed to strategically plan investment programmes. The LGA note that there will be significant costs in upgrading existing infrastructure in this way.

Processing all of the data in a way that provides insight will also be a significant new challenge, but is likely to become a key function in the near future. It is also likely that new technology will result in service redesign. For instance, the ability to access mobility services on demand could potentially allow otherwise isolated individuals to access mainstream services.

One of the particular challenges faced within dispersed rural networks is that the variable pace of technological adoption could exacerbate existing divides. Urban networks offer more commercial opportunities for private sector providers and there is a risk that opportunities enabled by technologies may exacerbate existing urban/rural transport inequalities.

In order to successfully harness innovations organisations will need a culture of openness to innovation. It will also require skills and expertise in new areas such as data processing, including how to monetise data. Organisations will have to

increasingly foster an entrepreneurial approach that allows risk taking and to maximise the benefits from these innovations.

Southampton University[iv] identify the role that new transport infrastructure plays in economic recovery and discuss the issues for policy makers and transport planners in identifying schemes that will deliver the best value, either in terms of economic benefit or societal aims. Planning for strategic infrastructure investment is complicated by the high cost and high public profile of schemes, and by the large number of actors involved in the planning process. Cost constraints mean that only a small number of transport projects will be constructed, making it all the more important that the available funding is spent on schemes that deliver the best return.

For much of the period from the 1960s to the early 1990s road construction followed a 'predict and provide' policy, with new infrastructure built to meet demand based on predicted economic growth. However, making it easier and quicker to drive generated additional traffic that filled up the new roads, and eventually led to a policy shift away from predict and provide towards a more nuanced approach based on demand management.

Comparing a predict and provide approach to behavioural measures encouraging more sustainable travel choices then extensive construction of new infrastructure leads to a 38% growth in traffic by 2050 compared to 2010, while behavioural change (leading to a shift away from car use for some trips) only gives a 3% growth in traffic.

Transport planners and policy-makers can have a significant impact on the shape of the future which will materialise. The starting point therefore for identifying how to assess future infrastructure requirements may be to identify what kind of future policy-makers wish to achieve. Many factors impact on transport demand and there is consequently a high level of uncertainty in longer-term forecasts. Southampton University identify an approach to analysis comprising two components, external 'scenarios' covering factors beyond the control of those planning the transport infrastructure system, and internal 'strategies' incorporating various policy options which planners can influence to at least some extent.

Consideration of the movement of goods may be given a lesser priority to the movement of people, but with freight transport making up 16% of all road vehicle activity in UK cities, and with lorries and vans performing 30% of their work load in urban areas, deliveries are a significant factor in congestion and pollution and measures to reduce the impact of deliveries can significantly benefit the urban environment.

Online shopping grew from 3% of total UK retail sales in 2007 to over 16.8% in 2015. This buying preference, coupled with new ways of fulfilling deliveries, has led to increased van traffic. Young people, especially those aged between 18 and 34 years make up a significant sector of online shopping.

Southampton University[v] identify the role that they and other higher education institutes play in deliveries from on-line retailers to campuses, and in particular student halls of residents. As such, halls of residence could be an ideal candidate for

consolidated deliveries, reducing congestion, parking infringements and improving air quality. However, student acceptance of a consolidated delivery service and a willingness to move away from same-day delivery would be critical to its success.

Public Health colleagues[vi] have summarised the public health intelligence relating to active travel, with specific reference to Hampshire. About 62% of adults in Hampshire are classified as overweight or obese. This is roughly in line with the national average, but admissions to Hampshire hospitals directly attributed to obesity or where obesity was a factor has increased above the national average, suggesting the life time health consequence for individuals of excess weight is likely to severe. Worryingly, children in Hampshire are becoming more overweight as they go through primary school. There is almost a doubling of obesity levels between reception year and year 6 children.

Energy colleagues have summarised changes in the energy market.[vii] UK electricity is derived from a mixture of fossil fuels (54%), nuclear (21%) and increasingly renewable sources (25%) and is distributed by the National Grid. It is estimated that £30 billion is needed to modernise the grid and to create a smart grid for more efficient distribution and better integration of renewable energy. The continuing reduction of costs for renewable energy technologies like wind and solar could mean that generating and using energy locally offers better value than generating power in relatively fewer, centralised locations. Energy lost in transmission over long distances can be reduced in a more locally generated and distributed energy supply, providing an opportunity for considerable efficiency savings.

The scale of change in the energy industry over the period to 2050 is anticipated to be considerable with the energy businesses of the future providing services more cleanly and efficiently, and offering more sophisticated and localised ways of meeting customers' energy needs. Digital tools will become increasingly integral to the energy industry as all parts of the supply and demand system are connected and work together. The complexity of matching energy demand with supply will require new technologies for energy storage, automation and real time data analytics, all at a scale to meet future energy demand.

A switch away from fossil fuels to renewable energy, with more efficient distribution and more local generation will better meet the demand for energy and the need to reduce CO_2 emissions to achieve climate change targets, but major energy users will also need to innovate to improve energy efficiency to reduce demand.

The National Grid estimate a full fleet of electric vehicles will increase in peak energy demand by 8%, with consumers likely to mostly charge off-peak. If additional demand for electric vehicles is met from additional renewable energy then air quality improvements at the roadside will be matched with reduced emissions at the generation site.

IT colleagues have summarised the status of connectivity in Hampshire and anticipated changes facilitated by innovation in IT technology.[viii] Access to fast broadband enables residents to access digital services, while the unavailability of fast broadband is likely to significantly affect access to these services. By the end of 2019 97.5% of properties in Hampshire will have access to fast broadband services.

Ofcom estimates that, in 2015, 17% of A and B roads nationally were not covered by any mobile operator's voice and text services (complete not-spots), and that 42% lacked coverage from all operators (partial-not spots). The lack of ubiquitous mobile coverage may impede the development of connected and autonomous vehicles as the existing mobile network would be utilized for Vehicle-to-Infrastructure connectivity. Beyond this a 5G mobile network will be required to meet the needs of future autonomous vehicles, although for safety reasons these vehicles will need to be able to operate without mobile coverage.

Artificial Intelligence (AI) is a fundamental technology for autonomous vehicles and offers the potential for radical changes in the workplace and in the home. Technology experts JCC Bowers[ix] have produced a whitepaper on artificial intelligence applied to fleet management. AI is effective at analysing large quantities of disparate data to gain insight a human would likely miss and is fundamental to autonomous vehicles.

As described earlier, big data analytics will lead to digital transformation in service delivery across sectors. Data literacy will be crucial in making the most of these new data tools. Big data analytics alone will not lead to better decision making, but new tools coupled with appropriately skilled staff will lead to new opportunities.

As organisations become more reliant on new data tools and potentially automated decision makings, organisations will also need to put in place appropriate provisions for security. As society becomes more reliant on technology, the impact of successful cyber attacks increases. Good cyber security is key to protecting against cyber attacks, and organisations should continually assess how it would continue to operate after a major cyber security attack on its IT systems, the UK banking system, the UK power generating systems etc.

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[i] Mobility, connectivity and energy. Internal technical report. 2018

[ii] Evidence to support Hampshire 2050 Commission. Atkins. 2018.

[iii] LGA Submission: Commission of Inquiry – Vision for Hampshire 2050. LGA. 2018.

[iv] Predict or Prophesy? Issues and Trade-Offs in Modelling Long-Term Transport Infrastructure Demand and Capacity. University of Southampton. 2018.

[v] I want it now - Understanding the logistics impacts of students' online shopping habits in halls of residence and the opportunities for consolidated parcel delivery services. University of Southampton. 2016.

[vi] Public health intelligence related to active travel, a driver for reducing air pollution. HCC. 2018.

[vii] Mobility, connectivity and energy. Internal technical report. 2018

[viii] Mobility, connectivity and energy. Internal technical report. 2018

[ix] AI Whitepaper. JCC Bowers. 2018.

5. Key points

Hampshire is a largely rural county in terms of land mass with just 15% defined as urban city or town, however 78% of the population live in urban areas.

Figure1. Transport network in Hampshire

Hampshire has 5,344 miles of road and 193 miles of railway track incorporating 49 stations, providing excellent transport links within the county. The Strategic Road Network of motorway and trunk roads, maintained by Highways England, provides wider connectivity beyond the county boundary. The ports of Southampton and Portsmouth provide passenger services to the Isle of Wight and Europe and international freight distribution, while the airport at Eastleigh provides air links to an increasing number of destinations, with both London Heathrow and Gatwick also within easy reach by road and rail.

While roads provide a vital link, road traffic is a major cause of outdoor air pollution, much of it attributed to cars and vans, particularly diesel vehicles which emit nearly ten times the nitrogen oxides (NO_X) and three times the fine particulate matter ($PM_{2.5}$) of their petrol equivalent. Emissions from lorries and buses are also a key source of NO_X and $PM_{2.5}$.

Outdoor air pollution has been linked to around 40,000 early deaths and hundreds of thousands of life years lost in the UK each year, with an average loss per person of life expectancy of approximately six months. This compares to the roughly 98,000

preventable deaths attributable to smoking in the UK.[x] The health damage from air pollution caused by traffic is most acute in more populated urban environments.

There is potential for dramatic reductions in pollution by switching to low emission cars and vans, and the Government will end the sale of new petrol and diesel cars and vans by 2040 with the aim that almost every car and van will be zero emission by 2050. It looks like electric vehicles, rather than alternatives such as hydrogen, will capture the market for low emission cars and vans in the short to medium term.

By 2050, total road traffic is predicted to grow nationally by between 17% and 51%, with the proportion of traffic in congested conditions forecast to range from 8% to 16%, compared to 7% in 2015[xi]. While it is generally recognised that emerging transport technologies will profoundly affect the way people travel, there remains significant uncertainty around the extent to which predicted traffic growth and congestion may be reduced.

The population of Hampshire[xii] continues to grow with an accelerated increase in the ageing of the population. Over a fifth of Hampshire's current population are aged 65 or older and this is projected to increase to almost 30% by 2041. Catering for the mobility needs of an aging population is likely to be a major mobility challenge by 2050.

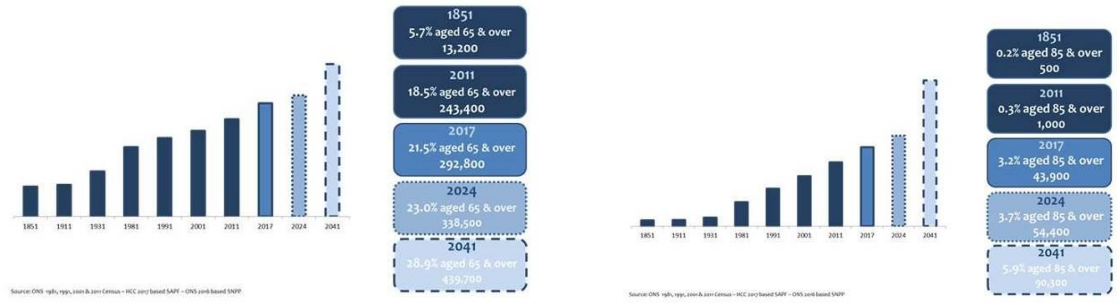

Figure 2. Population of Hampshire aged 65+ and 85+

Over 60% of Hampshire's population were classified as overweight or obese in 2016[xiii]. The life time health consequence for individuals of excess weight is severe. The associated cost to health and care service providers is also likely to be severe if obesity rates continue at this level. Catering for the needs of an overweight population will provide a further mobility challenge by 2050.

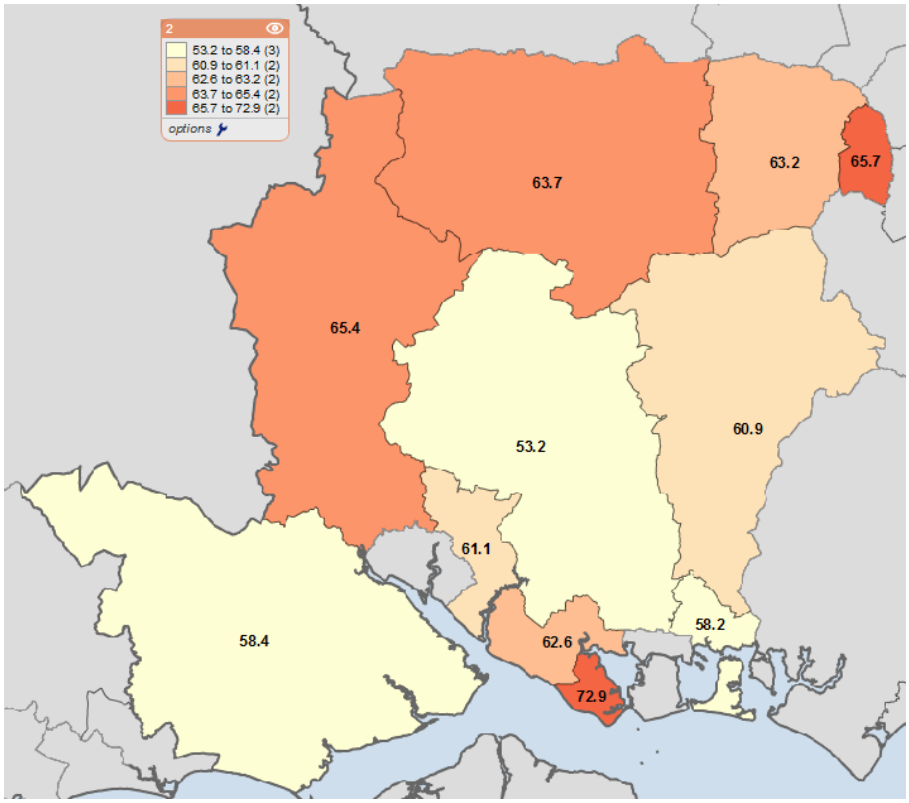

Figure 3. Adult overweight or obesity prevalence - % Adults (18+), 2016/17 (Source: Public Health England based on Active Lives Survey (ALS), Sport England)

Meeting these mobility challenges will require significant additional funding, but revenue from tax receipts (principally fuel duty) is likely to reduce rapidly as people switch to battery electric cars and vans. New funding models will therefore be required by 2050, and probably well before.

Transport policy and strategic transport planning is fundamental to achieving mobility outcomes and balancing the wider societal and environmental impacts of economic development. Building significant numbers of new homes to meet government housing targets will place an additional burden on transport infrastructure. Transport investment will be needed to unlock sites for development and to improve the wider transport network, but ideally new housing sites would be located to reduce car dependency and support sustainable transport networks including walking, cycling and public transport. The role of cycling and walking in tackling inactivity related health issues can be strengthened by increasing the numbers of people cycling and walking as a travel mode.

Modern urban centres have developed around access for motorists, but a new balance is emerging where traffic is being pushed out to create safe and pleasant environments, where the quality of the location as a destination is being emphasised. In redeveloping urban centres and devising new transport strategies, policy decisions will be needed regarding the balance between car mobility and place shaping. Future mobility strategies will need to deliver a better balance and give communities choice about whether to retain unhindered access for private vehicles or to accept more restricted access to provide a cleaner, safer environment.

Figure 4. mobility versus place

Bus services are essential to move large numbers of people in urban centres and to reduce traffic congestion by encouraging people out of their cars. Car sharing schemes provide another alternative option to private cars, although they are not suitable for people unable to drive, and who typically rely on public transport. Mobility as a Service (MaaS) is the integration of various forms of transport into a single on-demand service to offer a choice of mobility solutions and aims to provide customers with an integrated digital service combining available transport options.

MaaS is in its infancy but has the potential to address all of the themes identified in the Hampshire 2050 Commission of Inquiry. A MaaS offer specifically tailored to the needs of Hampshire residents and businesses could help the authority deliver its policy objectives, but is unlikely to make a transport offer a cheaper option for a customer who currently owns a vehicle, however if it can be shown to offer a flexible and on-demand service it may offer an alternative to buying a car in the future and encourage residents to accept more restricted access in order to provide a cleaner, safer environment. Future mobility strategies will seek to provide close to car-based convenience in a place designed for people.

MaaS and shared, on demand mobility options offer specific benefits for older people by making some activities easier and improving accessibility. This would similarly be an expected benefit for disabled passengers, and for people who have to give up driving for medical reasons.

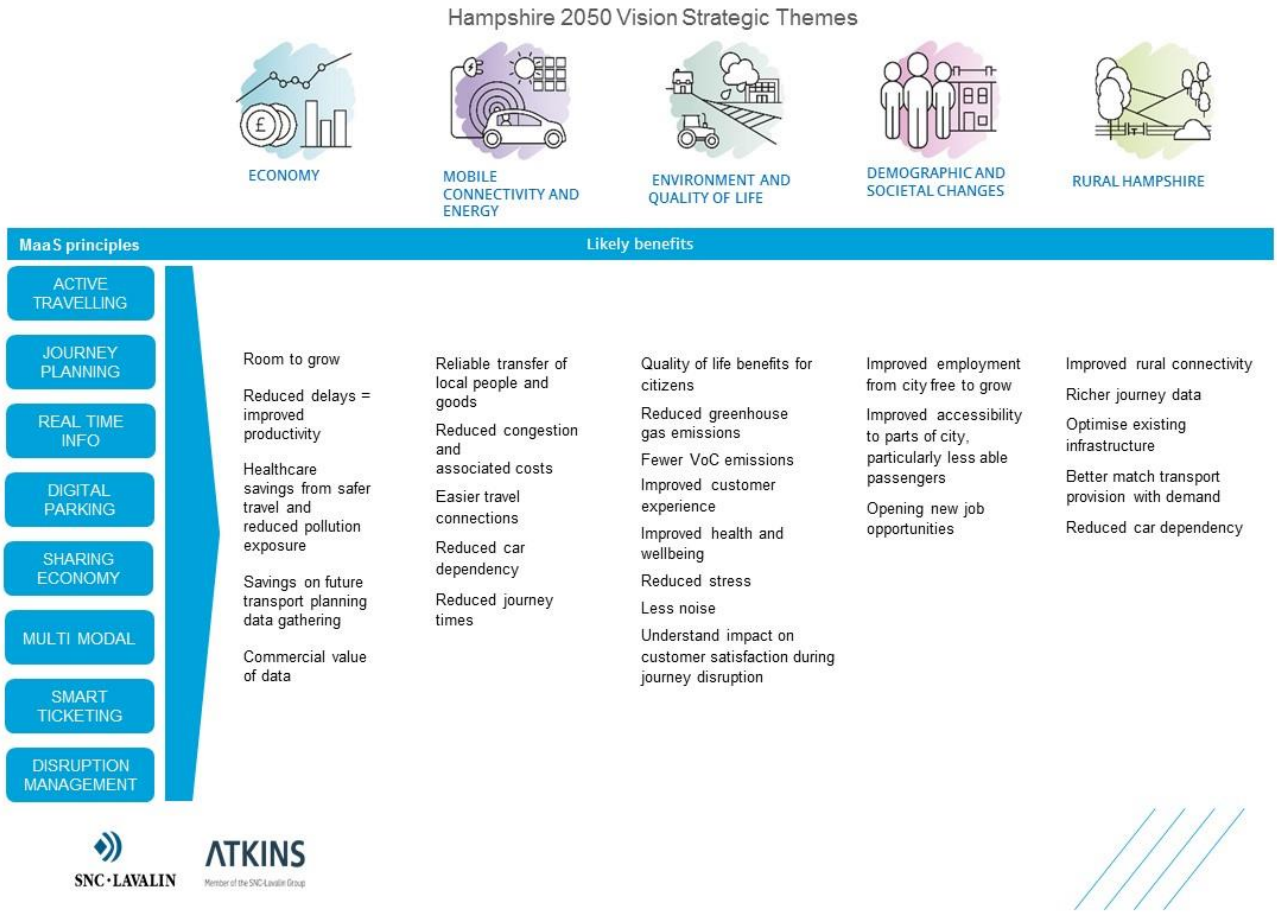

Figure 5 Mobility as a Service principles mapped to Hampshire 2050 strategic themes

Freight distribution and local deliveries is another area affecting transport strategy seeking to deliver a cleaner, safer environment. Consolidation centres located outside of city centres allow retailers to group together goods from all suppliers before making a delivery to a city centre store increasing the efficiency of deliveries and reducing congestion and air pollution in city centres.

The greatest technological innovation affecting mobility will be the emergence of autonomous vehicles, both for the movement of people and freight. Opinions differ on the timescales to adopt fully autonomous vehicles, and there will be a lengthy transition period as vehicles with no or limited automation are entirely replaced, with a mixed-fleet of partial automation in between. There are also some complex, urban environments that may prevent fully autonomous vehicles operating in all areas.

Road safety measures along with improved safety features in vehicles have been successful in reducing casualties in Hampshire by tackling the causes of collisions. More recently improvements have plateaued, but further improvements are expected with the advent of advanced vehicles capable of increasing automation.

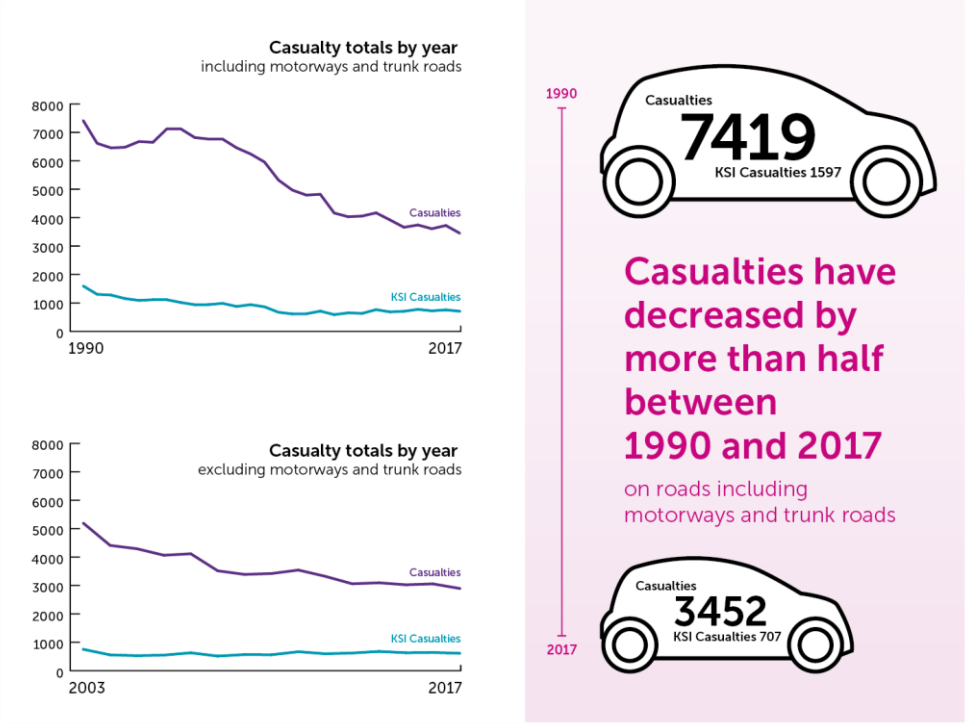

Figure 6 improved road safety in Hampshire

EuroRAP have predicted that about half of travel in 30 to 40 years will be in autonomous vehicles, with a reduction by about a quarter of all crashes, savings an estimated 2,500 lives and 25,000 serious accidents on UK roads[xiv]. Crashes involving conventional vehicles will continue, although reductions in numbers and the severity of injuries are anticipated with increased connectivity and automation.

Effective highway maintenance, necessary for automation anyway, along with specific safety engineering measures will continue to be needed over this period. A number of new asset types will be installed and require maintenance, including on-street charge points for electric vehicles and new roadside telecommunications devices to support connected and autonomous vehicles. Development in sensors and internet connectivity, combined with artificial intelligence and robotics, may transform asset management and improve business processes to make better use of network capacity and optimise the value from highways assets.

Future vehicles will be connected, autonomous, shared and electric. Future roads will need to be designed to provide unambiguous information and not rely on human interpretation to meet the needs of autonomous vehicles. An inflection point is anticipated when the needs for automated vehicles will override the benefits of some flexibility in highway management provision. Road design will begin to change around the need to facilitate automation through clear, unambiguous priority, which will benefit safety but may in the short term increase congestion. This may have implications beyond personal transport where facilities for public transport such as bus lanes and priority at traffic signals are affected.

Access to high-speed broadband is an essential utility for modern life. By the end of 2019 97.5% of properties will have access to fast broadband services. Most of the high-speed broadband is based on Fibre to the Cabinet which leaves the last

connection from the cabinet to the building as copper. The provision of a Fibre to the Premises will be increasingly important to provide greater capacity and reliability.

Mobile connectivity is another essential utility. Inadequate geographic mobile coverage affects users now and will likely hinder the future deployment of digital based services, potentially raising equality issues where mobile coverage is poor. Current 4G mobile networks provide connectivity, but have limited speed and capacity. 5G mobile networks are up to 100x faster, however the transmitter range is significantly smaller than those providing 4G networks. Therefore to deliver a strong 5G service, network providers will need to work closely with utility companies, rail and road agencies and all levels of government, to ensure 5G transmitters can be situated in the right locations and minimise implementation costs, which could delay or prevent deployment.

Artificial Intelligence (AI) enables current robotic technology to become more intelligent and start making increasingly complex decisions which have traditionally required human interaction. Within the next 30 years we will see much greater use of Narrow AI, where the technology is developed to solve single problems, but with increasing ability e.g. understanding language, which enables software to interpret written and spoken language, recognising tumours within radiography scans or finding relationships in data. General AI, where the same technology can be used to solve multiple wider ranging problems is not expected until at least 2050-2075.

Data literacy will be crucial in making the most of these new data tools and will require new skills within the traditional workforce. As organisations become more reliant on new data tools and potentially automated decision makings, appropriate provisions for security to safeguard these systems from malicious hacks will need to be put in place.

The energy businesses of the future will provide services more cleanly and more efficiently, and potentially at lower cost, utilising new energy technologies and digital enablers, with alternative models of delivery to the traditional grid system emerging and offering more sophisticated and localised ways of meeting customers' energy needs.

The continuing reduction of costs for renewable energy technologies like wind and solar power could see the old economies of scale being changed so that generating and using energy locally will represent better value than generating power in relatively few, large, centralised, locations.

With the rise of decentralised energy, local producer-consumers will need to flexibly manage the energy in the system and usage, and invest in new technologies to support this, including energy storage and digital technologies using big data, analytics and associated cloud computing. Digital tools will become increasingly integral to the energy industry as all parts of the supply and demand system are connected and work together.

Traditionally, consumers have purchased energy from one of the major energy suppliers, but with the cost of renewable energy generation equipment reducing, a rise in microgeneration is anticipated, where energy users generate their own power

and sell excess energy back to the grid which may be used for balancing wider supply and demand.

Innovation is already firmly embedded in the County Council's service delivery in relation to digital transformation and using technology to improve customer services and drive efficiency, but there may be opportunities beyond this to experiment in emerging technologies or to become an earlier adopter of new products and services with the specific objective of evaluating innovation. There are opportunities to establish innovation teams or to identify innovation champions to identify these opportunities. Both SNC-Lavalin Atkins and the Local Government Association identify a need to harness innovation to deliver mobility policy outcomes.

[x] The health costs of air pollution from cars and vans. University of Oxford and University of Bath. 2018.
[xi] Road Traffic Forecasts. 2018
[xii] Hampshire 2050 Theme 1 Demography. 2018.
[xiii] Public health intelligence related to active travel, a driver for reducing air pollution. HCC. 2018.
[xiv] Connected Future. 2016. National Infrastructure Commission.

6. Conclusion

At present, predicted traffic growth and levels of car ownership would indicate a continuation or worsening of existing traffic congestion; a continuation in effect of historic trends. Pollution might be expected to reduce as electric vehicles gradually replace petrol and diesel vehicles, but otherwise the problems of traffic could be anticipated to remain, with peak traffic periods extending well beyond current travel to work times. Reducing fuel duty as electric vehicles gain prominence will reduce tax revenue and potentially reduce the money flowing from central government to local authorities, which combined with increased social care and health costs of an increasing number of older residents and residents in poor health due to excess weight will mean less money for highways and transport services. This could lead to a further erosion of supported bus services and fewer mobility options for people without access to a car, with the most pronounced impact on rural communities and the increasing numbers of elderly Hampshire residents. Lack of transport options in rural areas could see communities here dwindle and could be expected to lead younger people in particular to migrate to the urban centres for access to employment.

Countering this bleak outlook is the emergence of a number of new technologies likely to provide both new mobility options and also change the nature of work and service delivery so that the need for travel is itself reduced. New connected and autonomous vehicles will change both the movement of people and the movement of goods. Over time these vehicles will radically change the way we travel, change the way highway engineers design roads, and change maintenance regimes for highway authorities. The emergence of on-demand mobility services, car clubs and other car sharing options will provide alternatives to car ownership, which may in turn offer new opportunities for redesigning public space, with a greater emphasis on the environment. Congestion will reduce as travellers switch to shared modes for peak period travel, and as autonomous vehicles provide for more efficient traffic management. Casualties will reduce too as autonomous vehicles reduce the potential for collisions.

Rail will continue to provide mass transit between urban centres, with autonomous buses or close-running platoons of autonomous pods operating on public transport routes in urban areas. New mobility services will provide first and last mile connections to these routes, with the potential to encourage walking and cycling to improve community health. Providing equivalent mobility in rural areas will be a challenge, but an ability to plan journeys using all options, including on-demand shared transport, will likely provide more opportunity than currently exists.

New transport policies and investment will be needed if the opportunities for future mobility are to be realised and a continuation of historic trends in traffic problems averted. Key to this will be the decisions made now about major housing developments that will build out over the next twenty years. Securing support for developments based on anticipated future mobility options rather than current dependency on private cars will be challenging until these mobility options become mainstream, but designing for current levels of car ownership risks poor space utilization.

The homes of the future will need high-speed broadband connectivity capable of supporting the requirements of new technologies and digital services. They will operate with smart grid technology to optimise their energy efficiency. Where vehicles are owned or stored at home they will be integrated into the energy system so that their batteries charge at the optimal time, store energy for other appliances or feed energy back into the grid when required. Greater energy efficiency, a switch to renewable energy sources, and technological innovation in electrical generation, distribution and storage will combine to create a more sustainable energy system, off-setting the additional energy demand from electric vehicles and new digital services, and helping achieve climate change objectives.

Major new developments present an opportunity to design and build for a community' future mobility, connectivity and energy needs, but potentially more important will be the policies and strategies developed to bring those same benefits to existing communities, and also to safeguard against the unintended consequences of innovation and to ensure inclusivity.

The opportunity also exists to reverse the existing community health impacts of current mobility options by encouraging active travel as a means to tackle obesity. In this regard, the future of mobility could be viewed less as a technology implementation project and more as a transport/public health policy objective.

Designing, maintaining and operating new technology in highways services will require new data competencies as well as traditional engineering and transport planning knowledge, and decisions will be needed on how to ensure staff have the right skills.

Transport infrastructure is a major driver of economic success. Planning for future mobility is therefore a fundamental transport planning activity. While technology is likely to be a key component of change, it is essential that using technology for technology's sake does not become the policy driver. Instead policy decisions should be made to tackle problems prioritised for action e.g. the needs of an aging population, rural accessibility etc, with strategies devised to address these problems. This will include how technology affects residents and businesses, and how to generate revenue/cost savings in services, but should avoid innovation that does not support policy outcomes.

As the costs for renewable energy technologies like wind and solar reduce then generating and using energy locally may become more attractive to meet customers' energy needs. A switch away from fossil fuels to renewable energy, with more efficient distribution and more local generation will better meet the demand for energy and the need to reduce CO_2 emissions to achieve climate change targets. New technologies for energy storage, automation and real time data analytics will be critical in achieving this transition.

Good connectivity combined with new tools such as Artificial Intelligence offers the potential for digital transformation in services. Data literacy will be crucial in making the most of new data tools and will require new skills within the traditional workforce. As organisations and society becomes more reliant on technology, the need for effective cyber security will be key to protecting against cyber attacks.