

Transport and Health Science Group: Infrastructure Sub Group

Policy Statement

Executive Summary

Transport - moving from one place to another – is fundamental to both the causes and solutions of the major personal and planetary health challenges facing human populations today.

A healthy transport system is one in which people make short journeys on foot or by cycle and make longer journeys by walking or cycling to a station and then using a train, a tram or a bus-rapid-transit system. A healthy transport system minimises the contribution of transport to climate change and maximises the potential for transport to reduce chronic disease and improve wellbeing through physical activity and inclusive interaction.

A comprehensive infrastructure policy therefore will see:

- rail or canal investment as a general higher priority than new roads
- local services as a general higher priority than high speed services
- high speed rail as a general higher priority than airports
- avoiding the need to travel through better internet facilities and better spatial planning as a higher priority than expanding the transport system
- walking and cycling routes as a higher priority than facilities for cars
- dealing with the problems of a saturated road system as a higher priority than delaying congestion by investment in additional road capacity
- systems of transport which can be operated by renewably generated electricity or other renewable sources as the only systems with a future
- the travel needs of differently abled passengers (including older people affected by frailty) as being as important as the travel needs of the ordinarily abled

To promote healthy, physically active lifestyles we need to provide better facilities for walking and cycling, including safe cycle routes and aesthetically attractive walking routes. Living streets play an important part of this. The effects of community severance need to be more fully understood and considered in infrastructure planning.

It is important that the built environment does not compel people to travel further by segregating activities and centralising facilities. A shorter working week could also reduce commuting whilst business meetings in cyberspace could reduce business travel (this policy statement was written without face to face meetings)

We need to have regard to the impact of transport infrastructure on natural habitats and hence on biodiversity.

The climate crisis will shape every aspect of human future. We need to stop investing in roads and airports and commence serious preparation for a zero-carbon transport system. This need not involve major impoverishment of life styles¹.

Ending private car usage almost entirely is the only means by which twenty-first transport can be sustainable across the globe. This will create multiple benefits, but can only be achieved if people are offered a comprehensive public transport network in which trains, trams, buses and demand-responsive 'dial-a-ride' and car-share systems allow all people to travel where they need.

A comprehensive system does not mean 'one size fits all', and local solutions, locally guided, are more important than large-scale or expensive mega infrastructure projects. Those will have their role, especially in step-changes of behaviour, but no single enterprise can achieve what must be a universal ambition.

Note

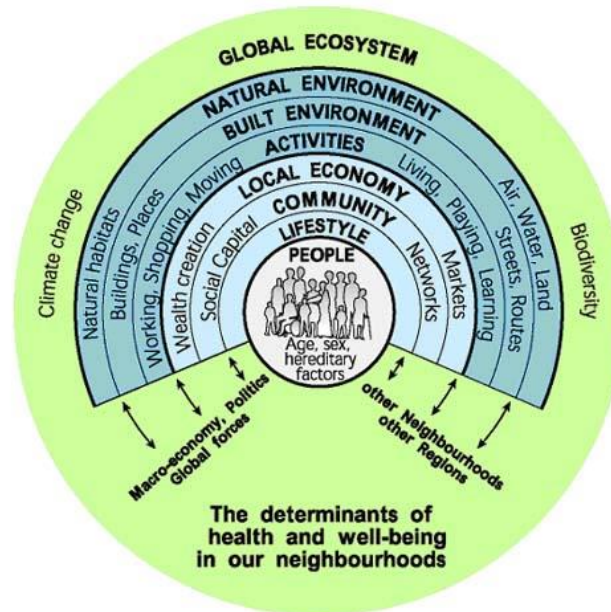
1. Much of what is discussed below is distilled from the THSG publication 'Health on the Move 2' (available at [www.transportandhealth.org.uk/]). Our thanks to the authors of that book. For expanded content and complete references for all our evidence-based statements please refer to relevant chapters.
2. This statement has been written with the UK in mind but many of its comments will be equally valid in other countries.

1. Transport and Health

Transport - moving from one place to another – relates to the health of our populations and our planet in a great number of ways. A healthy transport system is one in which people make short journeys on foot or by cycle and make longer journeys by walking or cycling to a station and then using a train, a tram or a bus-rapid-transit system. Door to door motorised travel is undesirable except for frail or disabled people or those encumbered by heavy luggage or in adverse weather conditions, as it loses the benefit of active travel. Self-driven cars are undesirable except in sparsely populated areas because of the congestion that they generate. High speed rail is preferable to aviation for environmental reasons although there is a question of whether high speed travel is needed at all now that cyberspace can make many business journeys unnecessary. However, aviation has its place across oceans or polar ice caps or for local travel in very remote areas like Antarctica or the Amazon. Freight is better carried by rail or water than by road, for environmental reasons, although the final stage of a freight journey will often be by road and systems which make it easier to transfer from road to rail or water, such as lorry carrying services or containers, facilitate this. We need to explore ways to reduce the carbon impact of shipping, perhaps by using sailing ships with auxiliary solar-powered electric engines.

¹ The introduction to Health on the Move 2 describes life in a world with a healthy transport system and shows that it is not an unpleasant or restricted life.

Everyone exists within an ‘ecosystem’ of influences; complex frameworks of interacting ‘health determinants’, some more easily modified than others. One conceptualisation of this is the Barton and Grant model of the wider determinants of health (Fig 1). We can use these ‘layers’ of influence to think about the interaction of transport with our health.



Lifestyle

The lifestyle people choose (or have no choice in) will include the extent to which they are physically active, with levels of physical activity known to be associated with risk of obesity, diabetes, mental health and CVD. Walking and cycling for transport are the easiest and most practical forms of physical activity for the greatest number of people and whether these can be undertaken depends on the transport environment. Are there cycle lanes? Are there pavements? Can people make a shorter active journey to a public transport hub for a longer journey? Are walking and cycling routes aesthetically attractive? Are streets crammed with cars and walking routes severed by main roads or is it pleasant to walk and easy to cross roads?

It is important to empower people to make healthy choices. There is no point asking people not to use their car if they live in an area where bus and rail services are limited. People do not choose to fly from New York to Los Angeles in preference to taking a 300mph sleeper train, having dinner as they leave New York and breakfast as they approach Los Angeles. They fly because the high-speed sleeper train does not exist.

Community and Local Economy

Whilst large retail parks are often only accessible by car, the local high street is likely to depend on access via foot and public transport. It will be important that the street and its pavements cater to a wider variety of users, including the elderly who may need seating and those in wheelchairs. Streets can connect communities but also sever them, often by creating impassable flows of traffic and/or high levels of noise. The quality of the streets – their appearance and whether they feel ‘safe’ – will impact on the social cohesion of the

neighbourhood, and local house prices. People make fewer friendships with their neighbours and have a narrower sense of personal ownership of the street if it is heavily trafficked. This affects both social networks and also affects security. Wider social choices are made within the available local environmental infrastructure, for example a decision to improve personal health by increasing walking and cycling is difficult to make when the local environment is perceived as potentially dangerous or hostile. Hostile environments are created by high levels of speeding, heavy local traffic flows, noise and pollution or where it is difficult to negotiate invasive street furniture designed for the motorist.

There are a number of options for local transport solutions which can be provided both within communities and by communities themselves. Community transport has utilised a range of vehicle options including minibuses, taxis and shared cars. Schemes tend to exist in areas where there is a limited customer base for conventional bus service or commercial market opportunities. Services have been supported financially by local transport authorities and education or health providers and others supported by local volunteers and still others by the private sector. However, all such schemes require a supporting infrastructure within which to operate.

With funding and resources, community transport can form an integral part of the local transport structure helping to provide accessible opportunities for disadvantaged groups – the old and frail, the sick and disabled, young people and those who choose not to own cars. Low incomes can further disadvantage many of these groups. .

For many people, a major factor in their satisfaction with their work, and with their health at work, will be their commute. More people in the UK travel further than ever before. We know that car parking charges at work are a key determinant of whether or not people choose to drive but many workplaces are inaccessible other than by car – including NHS trusts. Living, playing and learning may depend on the quality of transport links to access opportunities such as employment, education, healthcare, leisure facilities and fresh food, all of which need to be accessible within reasonable time, cost and ease. We also know that noise pollution from transport can adversely affect learning in schools whereas conversely the physical activity of walking or cycling to school improves academic performance. Crime also happens on transport networks, and designing network infrastructure to promote safety may involve attention to more than just injuries to individuals. 49% of women and 20% of men often feel scared waiting at the bus stop.

Transport is key to the accessibility of vital health services. It is important that all hospitals are accessible by frequent, reliable, acceptable public transport, ideally by more than one mode. Improving access has been a prime motivator for relocating many services into local neighbourhoods, reducing the need to travel for many. Interventions have included improved public transport information, financial support through the Hospital Transport Scheme, which supports those on a low income who need to attend appointments. Local health and transport authorities have made significant progress by working in partnership on the development of local transport plans which has resulted in improved public transport access and supporting information.

However, many of the users of hospitals are sick or disabled by the very nature of a hospital and so provision must be made for people who are not fit to use public transport.

Community transport and volunteer car-share schemes (such as Greater Manchester's Transport for Sick Children), can provide a bespoke community led answer to specific local access problems.

THSG believes that hospitals are only one of the destinations to which sick or disabled people want to travel and that it is better to have a comprehensive public transport service for transport-impaired people rather than special services focused on non-emergency patient transport

Built environment

Already it can be seen how the infrastructure of transport – the existence of cycle lanes, the quality of pavements, the size and height of roads, the number and quality of crossings, the presence of noise, the existence of benches, the cleanliness and safety of places where people walk and much more – greatly influences how people travel and therefore their health. Transport hubs such as major London stations are now also shopping centres, and many stations on the rail network will also have a café and/or shop with attendant issues around healthy food offers. When new houses or business parks are built, transport links are – or should be - built with them. Do we separate business and housing, forcing people to travel to work, or do we create opportunities for people to live close to their work?

Natural habitat

Transport can negatively impact the natural environment through noise and particulate pollution, disrupting areas of greenspace for humans, animals and plants. This has potential health significance, for example from the loss of ecosystem services provided by pollinators. It also affects quality of life – it is increasingly being seen that physical activity in natural environments has a greater health benefit than it does in other environments.

Global ecosystem

Transport requires resources, the most obvious of which being the fossil fuels still required to power the vast majority of road, rail, sea and air transport. Managing the demand for transport sustainably is a vital priority for any future transport system. The contribution of transport to the global climate crisis is significant, and will require radical change of behaviour and priorities to reverse, however the changes required align well with the needs of individual humans to be more active in their travel for their own health and immediate wellbeing.

THSG calls for comprehensive infrastructure policies which consider all these domains together

Given the description of a healthy transport system that we have described at the start of this document it is clear that a comprehensive infrastructure policy will see

- rail or canal investment as a general higher priority than new roads
- local services as a general higher priority than high speed services
- high speed rail as a general higher priority than airports

- avoiding the need to travel through better internet facilities and better spatial planning as a higher priority than expanding the transport system
- walking and cycling routes as a higher priority than facilities for cars
- dealing with the problems of a saturated road system as a higher priority than delaying congestion by investment in road capacity
- renewably generated electricity and other forms of renewable energy as the only appropriate power source for future transport systems

This doesn't mean that there is no place for a very small number of new roads, for example to service a new development, but it does mean that the balance of investment is currently wrong and that investment in "road improvement" and in airports should almost entirely be redirected immediately to investment in the future transport systems that a zero carbon world will require .

2. Existing transport modes

The question of congestion and the saturated road system

The congestion on road networks in most Western and Westernised countries is a perennial challenge to those attempting to move around in cars. However, the unmet need for relocation leads to new roads being filled and congestion returning to its original level.

A solution to the problems of congestion – on road and on rail – requires a whole-system approach. Better public transport systems, offering a great range of transport options (rail, bus, bike and others) may reduce road congestion but also unlock demand for travel which has previously been suppressed by the discomfort of travelling in a congested system. The other half of the solution is to reduce need to travel, for example via telecommuting.

Often discussed infrastructure solutions

Road expansion

As discussed above, road expansion cannot ease congestion for anything but a temporary period. Road improvements can shift congestion around the network but they cannot improve it. Road expansion may have a role in improving access to amenities or homes, however it does not necessarily follow that such roads would be for the use of private cars. Indeed, road expansion for the use of private cars should be seen as wasting investment which should have been directed to a viable future transport system.

Rail expansion

Rail expansion – which in the UK and elsewhere may include re-opening abandoned lines that already exist, and/or may mean more trains or more often on currently used routes – is an important part of improving a public transport offer. It has been demonstrated that in Europe cities with better rail networks also see higher bus usage; the capacity to travel further, faster by rail encourages people not to use cars in any stage of their journey.

Globally, substituting many journeys currently taken by aeroplane for journeys on international railway lines will be a necessary part of approaching climate change. Rail users are likely to spend some time per day walking, in the process to getting to stations and moving around them, which has obvious physical activity benefits.

Railways, like roads, can create noise pollution, air pollution or severing effects. However, they require much less land than roads, and railway banks – being off limits to people – are known to form important miniature nature reserves.

Cycle paths

Cycle routes are essential to improve cycle participation, but must be of adequate quality and safety, including where cycles must mix with road traffic e.g. junctions. Getting people cycling in towns and cities also requires a step change in the quality of digital journey planning, a large increase in cycle parking and/or the wider expansion of ‘turn up and go’ cycle hire schemes such as seen in London.

Good quality off-road cycle paths, such as those that can be established on old railways canal tow paths; cycle paths linking quiet streets into through cycle routes; and long continuous quiet routes formed by closing rat runs are popular with established and novice cyclists alike and should be a high priority for cycling investment.

It is worth mentioning that whilst some physical disabilities prevent bicycling, tricycles, hand-cycles and other machines can be promoted and should be able to share any infrastructure created.

In a zero-carbon transport system, increasing numbers of streets in cities will be ‘cycle only’.

Buses, guided buses, tramways et al

Guided buses and tramways provide vital opportunities for rapid transit in urban areas where any transport space is often rapidly dominated by private cars and private hire vehicles. Mixing light and heavy rail use in the same tracks may offer innovative solutions to crowding and surge responsiveness.

Train/Cycle combinations as a specific transport mode

The combination of the cycle and the train is a transport mode which can match the flexibility and speed of the private car, and at the same time introduce greater physical activity and be more environmentally friendly. People cycle to a railhead, take a train to another railhead, and then cycle to their destination. They either take their cycle with them, or they keep another cycle at the other end for a regular journey, or they hire a cycle at the other end.

Barriers to this important combined mode have historically included the prohibition of cycles on trains and trams due to crowding, inadequate bicycle storage capacity and/or safety and inadequate shower and change facilities at destinations. Removal of these barriers requires recognition that this is a distinct transport mode which needs to be developed and which has considerable potential to attract rail passengers, not simply an irritating minority group of current rail passengers. Where this has been done, as in the Netherlands, and in the case of CalTrain in California, it has been highly successful.

Lorry-carrying trains

Replacing road freight with rail would have substantial benefits for ecological sustainability and spatial demand. A longstanding challenge to such a policy has been how to ensure 'to door' delivery, given that rail lines cannot be built to all necessary end points. Replacing motorways with trains that carry freight containers already loaded on lorries, ready to drive away at the rail terminus, offers an innovative solution to these issues. Where these operate with high frequency and with a roll on roll off system (as in the case of the Channel Tunnel and in some Transalpine routes in Switzerland) they are sometimes referred to as "rolling motorways".

Cycle Freight

There is also considerable scope for use of cargo bicycles in the final delivery element of the freight system.

Issues in the current process of estimating the financial benefits of infrastructure solutions

In appraising proposed infrastructure solutions, we feel that current methodologies tend to overestimate the congestion benefits of roads and underestimate the network benefits of comprehensive public transport systems.

The question of benefit capture

Benefit capture is a system whereby non-user benefits are turned into a funding flow through a charge or tax. Simultaneously, social benefits are turned into a funding flow by taxing their opposite with a green tax, thus creating an economic incentive to avoid the tax. Road user taxes are an obvious way of disincentivising car travel and of funding projects which make roads less congested and more usable i.e. new or improved public transport infrastructure.

To accurately understand the potential benefits of infrastructure solutions, it ought also to be possible to capture other non-user benefit, such as the impact of transport on the value of land and on the promotion of economic activity, and on the health of the users of the transport system (using tools such as the WHO Health Economic Assessment Tool [HEAT] for walking and cycling).

3. Policy statement on novel transport modes

This section is intended to form a guide to new and emerging ideas on transport, with a vision of how these might be integrated, including technologies to make it possible.

Hyperloop

Hyperloop is a concept for a proposed mode of passenger and/or freight transportation, released by a joint team from Tesla and SpaceX. It is a sealed tube or system of tubes through which a pod may travel free of air resistance or friction, conveying people or objects at high speed.

Conceptual designs for a line between the San Francisco Bay Area and Los Angeles have envisaged propelling passengers along a 350-mile (560 km) route at a speed of 760 mph

(1,200 km/h), allowing for a travel time of 35 minutes, which is considerably faster than current rail or air travel times. There are concerns as to whether a project could be delivered within budget, given construction, development, and operation costs of a relatively new and untested technological solution. There are also concerns over the resilience of the technology, in that Hyperloop may be too susceptible to disruption from a power outage or terror attacks to be considered safe. Some critics of Hyperloop focus on the experience—possibly unpleasant and frightening—of riding in a narrow, sealed, windowless capsule inside a sealed steel tunnel, that is subjected to significant acceleration forces; high noise levels due to air being compressed and ducted around the capsule at near-sonic speeds; and the vibration and jostling. At high speeds, even minor deviations from a straight path may add considerable buffeting. This is in addition to practical and logistical questions regarding how to best deal with safety issues such as equipment malfunction, accidents, and emergency evacuations

On the other hand the scheme has less land take than other modes, can be powered by solar panels on the outside of the tube, has the flexibility to be built in a variety of settings, including elevated on poles, under water or underground as well as on the ground, and the speed has been claimed to be such that it has the potential to allow travel via hubs so that it could be used for local transport as well as intercity transport (however this has been disputed).

Interest in Hyperloop projects in China, Spain and the USA may make this technology an important part of future transport landscapes.

High speed miniature trains

In the UK, disused and decommissioned railways still trace many important routes of connectivity between key residential hubs and amenities. In the past disused railways have been incorporated in cycle ways or footpath systems, and we consider the promotion of walking and cycling the most important transport priority. However, there may also be scope for minimum gauge railways to share these routes, engineered with intention for significant speed. This would create an alternative to the car that would be more season-wide and potentially of use to those with longer journeys or with limited ability to walk, or heavy items to carry.

Cable cars/gondolas/aerial lifts

Cable cars have long been in used at ski resorts and tourist destinations. In recent times there has been an increase in their use as public transport in urban environments, especially in South America but also the Far East, Switzerland and the Emirates line in London. Gondolas are small high frequency cable cars often operating close to the ground and they could have a place to operate branch or link services.

Connected and autonomous vehicles

CAVs, also known as “self-driving vehicles”, “robot cars”, “autonomous vehicles” and “driverless cars”, is a vehicle that is capable of sensing its environment and moving with little or no human input. Autonomous cars combine a variety of sensors to perceive their surroundings, such as radar, computer vision, GPS, odometry and inertial measurement units. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Potential benefits include

reduced costs, increased safety, increased mobility, increased customer satisfaction, reduced crime and a need for less roadspace as vehicles can drive closer together both linearly and laterally. Safety benefits include a reduction in traffic collisions, resulting injuries and related costs, including for insurance. Automated cars are predicted to increase traffic flow; provide enhanced mobility for children, the elderly, disabled, and the poor; relieve travellers from driving and navigation chores; lower fuel consumption; significantly reduce needs for parking space; reduce crime; and facilitate business models for transportation as a service, especially via the sharing economy.

Vehicles can have different levels of autonomy from being autonomous on any road, to being autonomous only on roads they have learned, to needing various levels of human oversight. Those versions which need human oversight may be risky because people may be inattentive if the vehicle is predominantly self-driving.

As well as driverless cars we need also to consider driverless lorries, driverless buses and driverless trains. We have had driverless trains (or, strictly speaking, trains that are driven by the signalling system) for some decades now and the technology could be applied to any guided system. It is noticeable however that people have been reluctant to trust driverless trains and they are far less widely prevalent than they could be. Yet the safety problems of driverless trains are much less problematical than those of driverless road vehicles

Potential problems include safety, technology, liability, desire by individuals to control their cars, legal framework and government regulations; risk of loss of privacy and security concerns, such as hackers or terrorism; concern about the resulting loss of driving-related jobs in the road transport industry; and risk of increased suburbanisation as travel becomes more convenient. This may also have an impact on measures to reduce obesity and inactivity as inactive, sedentary travel becomes more convenient.

The question of whether driverless vehicles operate door to door with a single user, or station to station with shared use is an important one. The former would dramatically increase the number of cars on the road with an adverse effect on congestion that would offset the benefits of more efficient road use and would reduce walking and cycling. The latter would increase walking and cycling (at least as far as the station) and would reduce congestion to any guided system. It is noticeable however that people have been reluctant to trust driverless trains and they are far less widely prevalent than they could be. Yet the safety problems of driverless trains are much less problematical than those of driverless road vehicles

4. Particular problems – particular solutions

In this section we lay out some common problems facing communities in terms of transport and suggest brief outlines for solutions. Every situation will be different; we hope to suggest the breadth which can be addressed with infrastructure.

- Isolated rural town previously served by decommissioned railway

- If funding for infrastructure was redirected in accordance with the priorities that we have advocated in this document, there would be considerable scope to reopen railways.
 - Funding can also be generated by sharing the line with a heritage route or by finding ways to tap the benefits of increased land value
 - The Parry people mover offers a good economic way to operate a branch line from a junction station to a town and it is tragic that its successful use on the Stourbridge Junction to Stourbridge line has not been followed by the widespread reopening of short branch lines.
 - Where the line has already been incorporated into a cycle route, or whether this is an alternative use for the formation, a high-speed miniature railway might be an alternative which would leave space for the cycleway, or a greenway could be built on an elevated alignment above the railway.
 - If the railway formation has disappeared or been obstructed then a gondola system might be easier to build as it might more easily circumvent the construction. Alternatively a busway or tramway could bypass the obstruction along the roads.
 - If there is a good road link then an express luggage-carrying cycle-carrying coach service, linking to the railway and with through booking, could be an alternative
- Town seeking (or trying to avoid) a bypass
 - Bypasses have risen in popularity over the past fifty years as a means to address heavy road traffic and congestion in town centres. Simply creating a bypass, however, does not guarantee an overall improvement in quality of life. Given the need to shift away from the private car as a mode of transport we would strongly argue that if bypasses are to be built they should not have more capacity than the existing road, and that the existing road should be pedestrianised as far as possible. Creating additional road capacity is a short term solution that does nothing to ease the underlying issues
 - Addressing heavy traffic in town centres can be achieved through improving walkability and bikeability, giving priority to active and public transport. Many local journeys can be undertaken by bike or bus, and these may have the additional benefit of bringing trade to local high streets. Longer journeys 'passing through' the area should aim to switch to rail.
 - It may even be that money earmarked for a bypass could be used to develop a rolling motorway with vehicle carrying trains removing the vehicles from the road and allowing traffic calming of the road that remains. THSG has supported proposals for such a rolling motorway over the Woodhead Pass between Manchester and Sheffield instead of proposals for by passes and a new road tunnel.
- Suburban area seeking alternative to radial transport
 - Many cities run suburban routes from the city centre out to the suburbs. However it is important that the system should have radial routes which allow people to access a variety of destinations, including district and neighbourhood centres, without passing through the main city centre.

- Comprehensive systems are especially important for people with caring responsibilities. Research has shown that women, a gender with an above average proportion of people with caring responsibilities, are more likely to trip-chain (make a series of linked trips, for example dropping children off at school, then travelling to work, then shopping on the way to pick up the children from childcare and call in on an elderly relative, before finally completing the journey home. Systems based on radial routes to distant hubs do not accommodate this transport need and nor do infrequent, slow and circuitous bus systems. This can lead to trip-chaining being a cause of car use.
 - To cater for trip-chaining we need hubs to be much more local and to be linked to each other by fast frequent services.
 - Supplementing radial rapid transit routes (whether based on train, tram, cable car or bus) with orbital routes raises the same issues as we discussed above when considering reopening branch lines. Indeed the radial routes need to be supplemented by the reopening of branch lines.
 - The aim should be to bring a high frequency high quality rapid transit system, using various modes as appropriate in a linked system, to within walking distance of every residence, workplace, place of business or place of recreation. There should be a decentralised series of hubs, which should be linked to each other.
 - Sometimes the links in this system will be such that a scheduled service is not justified. There will also be people who are unable to walk to the station because of impairment or encumbrances such as heavy luggage. There will be destinations which cannot sensibly be drawn within walking distance of a station served frequently. These gaps in the system require a demand responsive service.
- Inner city seeking to pedestrianise streets
 - Switching the focus of streets from being a means of moving and parking cars to places where people can walk and cycle, and carry out their daily lives, is integral to the active, healthy and sustainable transport systems the modern world requires. Although there may be logistical and legal challenges, community action can achieve a great deal. Temporary and light touch projects, such as day-long road closures to promote a Play Street in the UK, can help develop interest and support for such measures.
- Large countries or groups of smaller countries considering how to reduce air travel and replace it with high speed rail or hyperloop
 - Potentially a high-speed rail system, with tunnels over the Straits of Gibraltar and over the Bering Straits, could link together the whole of Europe, Africa, Asia, North America and South America.
 - It could extend to Japan by a link to Russia from Hokkaido to Sakhalin and then from Sakhalin to Lazarev
 - It could extend to Australia by a string of tunnels linking islands across Indonesia. It might similarly be possible to link the Eastern Coast of the USA to the Northern and Eastern coasts of South America without the diversion

through Central America by building a series of tunnels from Florida to Venezuela via Cuba, Haiti, the Dominican Republic, Puerto Rico, the Windward and Leeward Islands, Trinidad and Tobago. However, in each of these cases the carbon cost and carbon benefit of such extensive construction would need to be carefully assessed.

- At 300 mph (potentially achievable by conventional high-speed trains) a ten hour sleeper train journey (two leisurely meals and eight hours sleep) is possible on journeys of 3,000 miles. At 450mph (potentially achievable by mag lev) this increases to 4,500 miles. At 760mph (potentially achievable by the hyperloop) it increases to 7,600 miles. A judgment needs to be made as to the potential of the mag lev and of the hyperloop to form the basis of an international system, as it would be sensible for all high-speed rail investment, other than short extensions of existing systems, to be based on the technology which is ultimately going to be the international system.

5. A vision of a comprehensive system

Ending private car usage almost entirely is the only means by which twenty-first transport can be sustainable across the globe. This will create multiple benefits, but can only be achieved if people are offered a comprehensive public transport network in which trains, trams, buses and demand-responsive 'dial-a-ride' and car-share systems allow all people to travel where they need.

In such a system, people undertake walking and cycling as part of almost every journey, effortlessly achieving physical activity targets and improving their own health. The air they breathe is cleaner and the streets they traverse are safer. When speed is needed, for example by emergency services, the system can adapt and provide clear routes.

A comprehensive system does not mean 'one size fits all', and local solutions, locally guided, are more important than large-scale or expensive mega infrastructure projects. Those will have their role, especially in step-changes of behaviour, but no single enterprise can achieve what must be a universal ambition.

