Addressing Real World Operations 10 and 11 (changes to physical infrastructure) but with a bearing on 1 and 2.

1. Introduction

1.1 Although autonomous vehicle technology appears to be advancing very rapidly and is incorporated to varying degrees in current road vehicles, nevertheless there are significant outstanding legal and ethical issues concerning use of its full potential on the general highway. It is not the purpose of this contribution to enter into this particular debate but to assume that: there will in the future be a mix of vehicles with different degrees of automation operating on the highway (a mix that will persist for some time) and ethical and legal issues are going to impede the full exploitation of the new technology on the general highway. I want to suggest a means of by-passing these difficulties to enable capable vehicles (vehicles classed at the high levels on the SAE’s classification) to make full use of their technology.

1.2 The Special Roads Act (1949) made possible the building of roads for the exclusive use of certain types of traffic, hence the introduction of motorways. By extending this approach and constructing roads for the exclusive use of vehicles driven in autonomous mode, current existential issues could be overcome. First, problems associated with the so-called ‘trolley problem’, should not arise. Second, and importantly, the driver by using the exclusive road would be recognised as formally accepting its ‘terms and conditions of use’. If, on the other hand, the ‘driver’ wishes to maintain a degree of control of the vehicle, she/he can exercise that choice but, to do so, has to revert to using the general highway.

1.3 There are significant ramifications of this suggestion for road design. When motorways were first introduced in the UK, vehicle technology adapted slowly to sustained periods of high speed driving: between 1958, when the first motorway was opened, and 1965 there was no national speed limit. As a consequence, vehicle breakdowns were common due to over-heated engines and tyre failure. Vehicle technology, however, slowly adapted. With exclusive, autonomous vehicle highways (AVHs), this early post-war process of the vehicle adapting to the highway could be reversed. Road design could be adapted to the vehicle technology.

2. Highways Designed for Autonomous Vehicles

2.1 First, because of ‘lane-assist’ technology (already installed in some vehicle types) AVHs could be constructed with narrower lanes. Early motorways were built with 10 foot lanes rather than the now standard 12 foot lane. The AVH could revert to 10 feet, or possibly narrower lanes. Vehicles sizes generally over time have tended to increase, including their width, but the advantage of autonomous control is that the vehicle would be navigated automatically to highways of suitable width; if the vehicle was too wide for the lanes of a particular AVH, its control system would foreclose entry to the vehicle. Indeed,
one might envisage narrow AVH being constructed for exclusive use by vehicles of a narrow width.

2.2 Second, one can envisage exclusive-use AVHs being used at higher speeds than the current national speed limit; with vehicle speed being adaptive to, for example, the horizontal curvature of the road. Consequently, an AVH could be constructed through-out its length with the option of much tighter curvature than is currently standard on motorways (and access points), in the knowledge that the autonomous vehicle’s speed would be continually adjusted to a safe operating speed.

2.3 Thus, this combination of progressive highway design features provides the opportunity to build AVHs that are much more sensitive to the visual environment than current highways. They would be narrower in cross-section and, for inter-urban AVHs, could follow contours of the land to a greater extent than current trunk roads. And, in so far as AVH were constructed within urban areas, such roads could wind their way more sensitively through the urban fabric, following lines of opportunity; perhaps following, for example, the route of old railway formations. Alternatively, tunnels of more limited gauge could be built more cheaply. An additional consideration is that on AVH there would be no requirement for road signage; the current smart motorways’ electronic gantries, for example, would, in essence, be incorporated within the autonomously controlled vehicle. AVHs, therefore, would have a lower vertical profile than the current highway with its mass of signs providing directions and giving safety guidance: exclusive AVHs provide the prospect of a clutter-free highway.

3. The economic case

3.1 The economic case for the construction of AVHs comes from the prospect of an improved benefit-cost ratio for AVH infrastructure. Reference has been made to removing the national speed limit from exclusive-use AVHs and therefore the prospect of vehicles operating at higher speeds, reducing journey times. The benefits come not only from higher maximum speeds but from the electronically disciplined nature of the vehicle’s operation. All vehicles on an AVH will be moving at a uniform speed within any particular external road environment. That is to say, for a stretch of highway through hilly country, designed with relatively tight horizontal curvature, the operating speed regime might be 60mph, for open country, 100mph or higher. This controlled speed environment and the automatic adjustment of the vehicle will itself reduce journey times. In addition, there are important gains for the vehicle ‘driver’, who is now free to engage in work related activity on smart phones/ laptops, to use the same in leisure mode, or read books/newspapers.

3.2 On the cost side of the equation, the potential for narrow vehicle lanes will reduce construction costs, albeit marginally. But, a larger gain could come from reducing the number of lanes needed; the AVH lane will have greater capacity because of the electronic coupling of vehicles in close formation (thus forming a de facto vehicle train). Consequently, exclusive AVH would have much greater capacity than their current motorway equivalents; conceivably a dual two (narrow) lane AVH could have greater capacity (possibly much greater capacity) than an existing dual three lane motorway. Indeed, it is possible to conceive of no more than a single directional lane (with hard shoulder). Envisage a vehicle break down in such circumstances: faced with an obstacle on the carriageway, vehicles will
be automatically slowed and guided around the obstruction (via the hard shoulder or, in low traffic density, the opposing lane) before speeding up again. Thus, large capacities at lower costs are in prospect with AVH, especially if use of them is made more exclusive than current motorways (i.e. restricted, for example, to light vehicles only).

4. Potential Case Study
4.1 The Government is currently proposing to construct HS2 at a cost (including rolling stock) of between £50bn. and £60bn. This is planned to reach Birmingham in the mid-2020s and Leeds /Manchester sometime in the 2030s. The object of the scheme has vacillated, but the chief, current object is to provide greater rail capacity along these routes. Over such a long planning horizon (common to most major transport infrastructure) the world can change considerably, if not dramatically, such is the pace of technological progress and institutional innovation. (HS1 European passenger forecasts, for example, were impacted significantly by the unforeseen introduction on a substantial scale of low cost airlines). There is a major risk (borne by the taxpayer) that by the time the first train runs (especially to Manchester and Leeds) the project has become technically obsolete. One element of risk comes from autonomous vehicle technology (fleets of autonomous National Express coaches for example) which might chip away at the rail market.

4.2 Why not anticipate such developments and in the process help the UK to take a lead in autonomous vehicle technology? Turn the planned formation of HS2 into the world’s first super highway for autonomous vehicles.

4.3 For reasons already explained, the HS2 rail formation will be wide enough to accommodate an AVH of at least a single directional lane and hard shoulder, and possibly more lanes (at least along certain stretches). The transformation will also overcome a major environmental drawback of HS2, its serious visual intrusion due to the size and number of electrification gantries required for high train-speeds. (The current electrification of the line from Paddington to Bristol and South Wales through some sensitive landscapes provides a good illustration of this problem). And, as for other environmental issues, it should be borne in mind that the road vehicle will be increasingly powered by electricity. From the point of view of the traveller in the autonomous vehicle she/he will be sitting in a formation of vehicles which at busy times will resemble a vehicle train (albeit running on electronic tracks), except in this instance the train seat will be substituted for by a private (vehicle) ‘compartment’.

4.4 There appears to be a case, I believe a strong case, for the Government conducting a cost-benefit analysis on the HS2 conversion proposal (or on a similar exclusive AVH project) in the process taking into account the potential boost AVHs might give to Britain’s hopes to be a world leader in the new technology.

5. Summary
- Ethical and legal culpability problems are likely to slow exploitation of the full potential of autonomous vehicles operating on the general highway.
- These problems could be circumvented by the construction of exclusive roads for use by autonomous vehicles operated in fully autonomous mode.
• The design of such roads could be adapted to autonomous vehicles and the ability of such vehicles to follow a precise track at speeds automatically adjusting to external conditions. Narrower, de-cluttered highways could thus be constructed with environmental gains.

• The narrower, exclusive AVHs could achieve substantial increases in capacity compared with an equivalent motorway.

• Higher speeds and higher road capacities (together with benefits to the ‘driver’) hold out the prospect of favourable economic returns from investment in AVH infrastructure.

• It is suggested that the Government conduct an evaluation exercise to test the proposal that the formation of the planned HS2 is used for constructing the world’s first super highway for the exclusive use of autonomous vehicles.

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