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Governance, flows, and the end of the car system?

John Urry *

Department of Sociology, Lancaster University, United Kingdom

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A B S T R A C T

The 'steel-and-petroleum' car is one of the most significant contributors to anthropogenic environmental change especially with its continued rapid growth in the world's most rapidly developing countries. This paper examines the intersections of the flows of new fuel systems; new ways of producing car bodies and new systems of managing personal mobility; and especially how these could be governed on multiple levels to overturn this car system. Complexity theory is deployed to examine what might tip these governmentalities and flows into a post-car system.

> They paved paradise and put up a parking lot (Joni Mitchell, 'Big Yellow Taxi', *Ladies of the Canyon*, May 1970)

> in transportation, unfortunately, the old-fashioned linear notion of progress prevails … the result is that we have actually crippled the motorcar, by placing on this single means of transportation the burden for every kind of travel. (Lewis Mumford, 1953, p. 177)

Viewed through the lens of complexity, I argue that automobility is a self-organising, non-linear system that presupposes *and* calls into existence an assemblage of cars, car drivers, roads, petroleum supplies, and other novel objects and technologies. The system generates the preconditions for its own self-expansion, including elements, processes, boundaries, and other structures, and the unity of the system (Luhmann, 1990, p. 3). In this paper, a framework of complex systems theory is used to investigate the character of this automobility system. I then consider certain possible 'post-car' systems that might develop and assess what conditions might engender a 'post-car' system (see Urry, 2007; Dennis and Urry, 2008, for other elaborations).

1. Complexity

The complexity sciences examine how components of a system through their dynamic interaction 'spontaneously' develop collective properties or patterns that are not implicit, or at least not implicit in the same way, within individual components (see Urry, 2003, for a fuller account). Complexity investigates emergent properties, or regularities of behaviour that transcend the ingredients that make them up. Complexity argues against reducing the whole to the parts. In so doing it transforms scientific understanding of far-from-equilibrium structures, irreversible times and non-Euclidean mobile spaces. It emphasises the nature of strong interactions occurring between the parts of systems, often without a central hierarchical structure that 'governs' and produces outcomes. These outcomes are both uncertain *and* irreversible.

Time and space are not to be understood as the *container* of bodies that move along these dimensions (Capra, 1996; Casti, 1994; Prigogine, 1997). Time and space are viewed as *internal* to the processes by which the physical and social worlds themselves operate, helping to constitute their very powers. A further consequence of this fluidity of time is that minor changes in the past can produce potentially huge effects in the present. Such small events are not 'forgotten'. Chaos theory in particular rejects the common-sense notion that only large changes in causes produce large changes in effects (Gleick, 1999). Q1 Rather relationships between variables can be non-linear, with abrupt switches occurring; the same 'cause' can in specific circumstances produce quite different kinds of effects (Nicolis, 1995).

Complexity theory sees systems as being 'on the edge of chaos', where the components are not fully locked into place but yet do not dissolve into anarchy. Chaos is not anarchic randomness; an 'orderly disorder' is present within such dynamic systems (see Hayles, 1999). A particular agent rarely produces a single and

* Tel.: +44 1524594179.
E-mail address: j.urry@lancaster.ac.uk

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confined effect. Interventions or changes will tend to produce an array of possible effects across the system in question. Prigogine describes these system effects as ‘a world of irregular, chaotic motions’ Prigogine (1997, p. 155).

Thus complexity theory examines how components of a system, through their interaction, ‘spontaneously’ develop collective properties or patterns. If a system passes a particular threshold with minor changes in the controlling variables, switches may occur and the emergent properties turn or tip over. Thus, a liquid turns or tips into a gas, or small temperature increases turn into global heating (Byrne, 1998, p. 23; Lovelock, 2006). I now examine one such complex system, namely the car system and how it may come to tip into an alternative.

2. Complexity and the car

The complex system of automobility stems from the path-dependent pattern laid down in the 1890s. Once economies and societies were ‘locked in’ to the ‘steel-and-petroleum’ car, massive increasing returns resulted for those producing and selling those cars and their associated infrastructure, products and services (Arthur, 1994). Social life came to be locked in to the mode of mobility that automobility both generates and presupposes. This mode of mobility is neither socially necessary nor inevitable yet it seems almost impossible to break away from. Relatively small causes set up what seems to be a long-term pattern that has ensured the preconditions for automobility’s self-expansion over the past ‘century of the car’.

In the 1890s, the three main sources of energy for propelling vehicles had been gas/petrol, steam and electric batteries, with the latter two being said to be more ‘efficient’ (Motavalli, 2000). Petrol fuelled cars were established for small-scale, more or less accidental reasons, partly because a petrol fuelled vehicle was one of only two to complete a ‘horseless carriage competition’ in Chicago in 1896. Once established, the petrol system got ‘locked in’. Small causes occurring in a certain order at the end of the 19th century turned out to have awesome consequences for the 20th century. Soon a ‘multi-level’ array of other industries, activities and interests came to mobilise around the petroleum-based car, further strengthening its path dependency. As North writes: ‘Once a development path is set on a particular course, the network externalities, the learning process of organisations, and the historically derived subjective modelling of the issues reinforce the course’ (North, 1990, p. 99; and see Geels, 2006).

Predicting traffic expansion and then providing for it through new road building became especially marked during the middle years of the 20th century (Cerny, 1990, pp. 190–194). The ‘steel-and-petroleum’ car’s unrelenting expansion and domination over other mobility systems came to be viewed as natural and inevitable; nothing, it was thought, should stand in the way of its modernising path and capacity to eliminate constraints of time and space (Sachs, 1992; although Ford did experiment with methanol-based fuel). Over the 20th century, this naturalisation of the car and its increasingly extensive lock-in with multiple institutions/organisations necessary for its expansion was facilitated through new discourses of governance, that drivers had to be qualified and appropriately trained and how pedestrians should behave so as to be able to cross roads safely in spite of their increasing monopolisation by cars.

As a consequence, institutions matter a great deal in how systems develop, contributing to their long-term irreversibility. The effects of the petroleum car over a century after its chance establishment show how difficult it is to reverse locked-in processes, as billions of agents co-evolve and adapt to form a system of interdependent agents and relations—a complex assemblage or system that ‘constitutes’ the ‘steel-and-petroleum’ car.

‘Path dependence’ is thus central to how patterns of socio-technical development are locked in through increasing returns. This notion emphasises the ordering of events or processes over time. *Contra* linear models, the temporal patterning in which events or processes occur influences the way that they eventually turn out (Mahoney, 2000). Causation flows from contingent minor events to hugely powerful general processes that through increasing returns get locked in over lengthy periods of time. With path dependence, relatively deterministic patterns of inertia thus reinforce established patterns through processes of positive feedback. This escalates change through a ‘lock-in’ that over time takes the system away from what we might imagine to be the point of ‘equilibrium’ and from what could have been optimal in ‘efficiency’ terms, such as a non-QWERTY typwewriter keyboard or, especially important here, electric forms of powering cars (Motavalli, 2000).

One billion petroleum-fueled cars were manufactured during the last century, with now over 600 million cars roaming the world. World car travel is predicted to triple between 1990 and 2050 (Hawken et al., 2002). Country after country is developing an ‘automobile culture’ with the most significant now being China. By 2030 there may be over 1 billion cars worldwide (Motavalli, 2000, pp. 20–21, 231–232). There are of course many changes in where those cars get made, the firms that dominate with the notable growth of lean manufacturing in Japan, and the changing economies of scale with the need for minimum plants producing over 200k units a year (see Womack et al., 1991).

The ‘structure of auto space’ (Freund and Martin, 1993) forces people to orchestrate in complex and heterogeneous ways their mobilities and socialities across very significant distances. The urban environment, built during the latter half of the 20th century for the convenience of the car, has ‘unbundled’ territorialities of home, work, business, and leisure. Members of families are split up as they live in distant places requiring complex travel to meet up intermittently. People inhabit congestion, traffic jams, temporal uncertainties and health-threatening metropolitan environments as a consequence of being encapsulated in a privatised, cocooned, moving capsule (Whitelegg, 1997; Miller, 2000).

Overall automobility is a system in which everyone is *coerced* into an intense *flexibility* (see Urry, 2007, chapter 6). It forces people to juggle tiny fragments of time so as to deal with the temporal and spatial constraints that it itself generates. Automobility develops ‘instantaneous’ time, to be managed in highly complex, heterogeneous, and uncertain ways, in an individualistic timetabling of fragments of time. Thus, the car system is a Janus-faced creature, extending individuals into realms of freedom and flexibility but also constraining them to live spatially stretched and time-compressed lives. The car is the ‘iron cage’ of modernity, motorised, moving and privatised. Automobility thus produces desires for flexibility that only the car system can satisfy. Yet in order to cope with the ‘mass’ adoption of individualised automobility, a systemic assemblage of artefacts, support and forms of governance are required and develop.

‘Automobility’ is a hybrid assemblage, of humans (drivers, passengers, and pedestrians) as well as machines, roads, buildings, signs, cultures, and modes of governance with which it is intertwined (Urry, 2007, chapter 6). It is not the ‘car’ as such that is key but the *system* of these fluid interconnections since: ‘a car is not a car because of its physicality but because systems of provision and categories of things are “materialized” in a stable form’ that then possesses very distinct affordances (Slater, 2001). It is a modern day Leviathan: ‘automobility stretches its six fingers—production, possession, pipelines, projection, pressure and power—to tighten its global grasp upon humankind’ (Latimer and Munro, 2006, p. 35). One would predict that whatever else happens in the twenty first century, the current car and its flows and systems of supportive governance are here for the foreseeable future; there will be what Adams terms a car-based hypermobile Q2 'business as usual' (Adams, 1999).

3. System change

But a key feature of complexity thinking is that, although there are long-term irreversibilities, nothing is fixed forever, not even the universe (Davies, 2001). Other worlds are possible even if they are not necessarily 'better worlds'. Abbott maintains that there is: 'the possibility for a pattern of actions to occur to put the key in the lock and make a major turning point occur' even if the timing and processes involved are impossible to predict accurately Q3 (Abbott, 2001, p. 257). But so far most thinking about the 'future' of automobility and its governance is linear (but see Geels, 2006). The question has become whether one particular aspect of the 'car' can be changed through state or corporate actions, and what will be the consequences of a linear change such as improved fuel efficiency, or reduced weight-to-power ratio, or increased car sharing. This dominant linear approach is found in most Government or official assessments of alternative futures. For example, the UK's Royal Academy of Engineering's Report on *Transport 2050* is typical in not treating automobility as a complex system that is interconnected with a multitude of economic, governmental, and social practices, or with how a set of small changes could in very particular circumstances provoke entire system change (Royal Academy of Engineering, 2005).

And given the exceptional scientific, social scientific, and policy significance of climate change, it is now seen as essential to limit carbon use within transport since it accounts for one-third of total carbon dioxide emissions and is the fastest growing source of such emissions (Geffen et al., 2003; 'climate change' generates almost 22 m hits on Google: 31.01.07). This growth in transport-generated carbon emissions stems from the projected growth of car and lorry travel within China and elsewhere throughout the world, the rapid growth of especially cheap air travel, and the increased 'miles' flown by manufactured goods, foodstuffs, and friends (see Larsen et al., 2006, on friendship and relationship miles). In the year 1800, people in the US travelled on average 50 m a day; they now travel 50 km a day (Buchanan, 2002, p. 121). Today, world citizens move 23 billion km; by 2050 that figure is projected to increase four-fold to 106 billion (Schafer and Victor, 2000, p. 171). Moreover, there are potential alternatives to carbon-based systems for powering 'cars' and so reducing carbon use with regard to personal mobility is high on the agenda of global governance (Motavalli, 2000; Giddens, 2007, pp. 188–189). Such a move from a carbon-based transport system is increasingly formulated as a short-term imperative that would generate long-term savings if it could be achieved in time. There is a 'high price to delay' (Stern, 2006, p. xv; the Liberal Democrat Party in the UK has proposed ending petrol-using cars by 2040). This is a potentially crucial change in the economic and governance landscape around the world that is calling into being a different future, partly expressed as a competition between the US and the EU as rival systems of global governance (see Rifkin, 2004).

Some argue that we have reached the limits of the car system especially as it is simultaneously being realised by governments and corporations that oil supplies around the world are beginning to run down. Peak oil production occurred in the US as far back as 1971 and it seems that oil production worldwide will have peaked by 2010 since new oil and gas fields are not being discovered at the same rate as they had been in the past (Heinberg, 2004; Rifkin, 2002, chapter 2). Energy will be increasingly expensive and there will be frequent shortages especially with the world's population and per capita consumption of oil and gas continuing to rise. Leggett (2005) brings out the complex catastrophic linkages of oil shortages and climate change. Such declining oil supplies will generate significant economic downturns, more resource wars and lower population levels. Rifkin (2002, p. 174) claims that the oil age is 'winding down as fast as it revved up'. Indeed the US seems to have based much of its foreign policy on the concept of peak oil for 30 years and this accounts for Middle Eastern oil wars (Heinberg, 2005) as well as being linked to the 'global war on Q4 terror' that might be seen as a proxy for a global war by the US to access oil and other energy supplies. The US is disproportionately greedy in its consumption of worldwide energy (Nye, 1999).

Crucial to thinking through potential change is that systems move across thresholds or what are often referred to as tipping points (Gladwell, 2000; Pearce, 2007). Tipping points involve the notion that events and phenomena are contagious, that little causes can have big effects, and that changes can happen dramatically when the system switches, rather than in a gradual linear way. Examples include the consumption of fax machines or mobile phones, when at a moment every office needs a fax machine or everyone needs a mobile. In this context, economic gain derives not from scarcity as in conventional economics but from others in the system also being consumers (Gladwell, 2000, pp. 272–273). Thus, the issue for those governing the current car system is whether a tipping point could occur when suddenly the world turns its back on 'automobility'.

So is it possible to transform the entire 'mix' of relations formed around the current car system? Any post-car future would involve the futures of lifestyles, cities, architectures, thinking and social practice. Geels (2006, p. 165) argues more generally that such system innovations: 'are not merely about changes in technical products, but also about policy, user practices, infrastructure, industry structures and symbolic meaning etc'. What are thus the array of non-linear changes that could shift the car system to a different path-dependent pattern? Is there a tipping point that could create a break with the current car system? Complexity theory shows how a system shift would involve various interdependent small transformations occurring in a *certain* order that can tip the system into a new path (Urry, 2003; Gladwell, 2000).

I suggest below that there are some technical-economic, policy, and social changes that are currently laying down the seeds of a new mobility for the rest of this century. If they occur in the 'right order', which we can probably only know in retrospect, they *could* produce a 'post-car system'. These small changes that might tip into a new assemblage operate at multiple levels of the technological, economic, social practices, and governmentality, as argued in the UK's major scenario building for 2055 (Foresight, 2006; and see Leggett, 2005, p. 165). I now briefly summarise these small developments that have the potential for system-changing outcomes.

4. Small changes

4.1. New fuel systems

The internal combustion engine is principally fuelled by the primary energy sources of oil, natural gas, and coal to produce petrol/gasoline, diesel, and LPG (liquefied propane gas). In 2005, the worldwide transport sector had a dependency on oil at 98% representing 50% of global oil consumption and 20% of energy consumption. This followed an annual average growth rate of over 2% per annum (Pinchon, 2006). How to escape this dependency?

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Fuel alcohols (ethanol/methanol) can be produced from a range of crops, such as sugar cane, sugar beets, maize, barley, potatoes, cassava, sunflower, and eucalyptus (Salameh, 2006). Two countries that have developed substantial biofuel programmes are Brazil (ethanol from sugar cane), and Russia (methanol from eucalyptus). The worldwide production of ethanol in 2005 is around 37 million tonnes, 80% being used as fuel (Pinchon, 2006). The production of ethanol for fuel grew 15% in 2000–2005, with an estimated worldwide ethanol fuel use in 2050–2100 around 33% (Pinchon, 2006). A Biofuels Research Advisory Council report suggests that by 2030 the European Union should supply up to 25% of its transport fuel by CO_2-efficient biofuels (BRAC, 2006). Although biofuel usage cuts down dependence upon foreign oil imports and is a cleaner material, the main problem is the limited availability of agricultural cropland, and that the shift from food to fuel crops would raise food prices. For either the US or EU to replace 10% of their present transport fuels with biofuel using today's technologies would require up to 40% of their cropland (Salameh, 2006). The BRAC report on future European biofuel usage recommends securing safe and consistent biofuel imports as well as developing possible alternative biotechnology programs (BRAC, 2006). Biofuels may be significant in increasing future energy securities, yet research is still needed to engineer biofuel that is not dependent upon monocrop plantations.

With regard to hydrogen, the costs of producing it from renewable energy sources are high and likely to remain so (Romm, 2004, p. 3). Infrastructure is also a problem. Two key issues are where hydrogen is produced, and how it is stored on the hydrogen vehicle. Hydrogen, being highly corrosive, has the potential to make current gas pipelines brittle, thus requiring a whole new infrastructure to be established. Overall, 'hydrogen fuel cell cars are unlikely to achieve significant market penetration in [the US] by 2030' (Romm, 2004, p. 115). Similarly, Heinberg (2004, p. 129) notes that 'we need a solution now, not decades from now'. In this respect, hydrogen seems a difficult short-term strategy although it may occupy a particular niche in a post oil future.

Current research is rather seeking to produce cheaper, more efficient lithium-ion batteries that are faster to charge. MIT's new lithium battery is capable of making the battery recharge up to 10 times faster (Trafton, 2006). However, the process still needs to be made cheaper before it can be commercially produced.

A variation on the hybrid-electric vehicle (HEV) is the 'plug-in hybrid' car (Plug-In Hybrid Electric Vehicles: PHEV). PHEVs are grid-connectable Hybrid Electric Vehicles that typically consume 50–90% less of any kind of conventionally used fuel. The PHEV is the basis for a viable Vehicle-to-Grid (V2G), Distributed Generation (DG) vision, whereby the car can be plugged back into the grid when not in use, both to recharge but also to return some of its unused energy during peak demand. In this way, credit can be earned which also encourages non-peak-time driving. This peer-to-peer grid connectivity mirrors the web-like infrastructure of the internet and allows for distributed participation. This is similar to Rifkin's (2003) peer-to-peer vision for a hydrogen economy.

4.2. New materials

A future 'efficient' personal vehicle would not be made of steel. The weight ratio needs re-modelling since at present the car 'needs only one-sixth of its available power to cruise on the highway and severalfold less in the city. The result is a mismatch not unlike asking a three-hundred pound weightlifter to run marathons' (Hawken et al., 2002, p. 27). It is possible that a shift in materials will influence the adaptation of smaller, lighter, safer, and smarter 'personal vehicles' that increasingly fit within an urban–industrial assemblage. New materials will also facilitate the current drive towards 'Intelligent Transport Systems'.

Another virtue of new, lighter materials is that 'personal vehicles' will be more recyclable. The EU proposes recycling 85% of vehicle components and converting 5% into energy. By 2015, 95% of vehicle components will have to be recycled. This signals a move towards systemic thinking in terms of industrial manufacture and materials. Industrial and social flows may be forced to act as in ecological flows—in self-reflexive and recyclable processes, rather than in wasteful, linear flows. Too much energy is being wasted within the car itself—through heat dissipation from the engine, exhaust, tyres, and so on. Recycling of energy will become more prominent within energy/fuel systems.

Globally, automobile manufacturers are intensively researching vehicle materials that will provide light material composition without sacrificing strength. Hawken et al. (2002) have developed a 'hypercar' made of advanced polymer composite materials. Other technologies include aluminium and nanotechnology which may make possible carbon-based fibres 100 times stronger than steel and at one-sixth the weight (US Department of Transportation, 1999, pp. 4–5). Nano-engineered materials are likely to become part of a future re-designed vehicle. State-of-the-art research claims to have developed polymers filed with nanoscopic holes that are 'nanoporous polymers' for absorbing and storing hydrogen at increased rates for hydrogen cell fuels (Graham-Rowe, 2006). Also the production of much smaller 'personal vehicles' rather than four-person, family-sized cars for crowded urban spaces should increase (current examples include the Mercedes Smart Car, the Nissan Hypermini, Nice's Mega City, and the Reva G-Whiz).

4.3. 'Smart-car' technologies and communications

New players will emerge in the transportation construction market, such as electronics software companies as they integrate their products into hybridised 'personal vehicles'. At the same time as information is being digitised and so released from location, cars, roads, and buildings are being increasingly rewired to send and receive digital information in newly re-configured intelligent transportation systems (ITS). With the increase in the use of sensors future automobiles may resemble computers with wheels rather than cars with chips. Such 'personal vehicles' may cross-over into being driven more and more by software than by hardware, and adaptable learning 'autocars' may develop to integrate into the software based urban infrastructure. A tipping point may occur that coerces individual mobility into an assemblage of 'smart' technologies. Thus, there is the re-embedding of information and communication technologies (ICT) into moving objects. These reconfigurations represent an epochal shift as 'cars' are being reconstituted as a networked system rather than separate 'iron cages', as a potentially integrated *nexus* rather than a parallel *series*. This could produce a shift from the modern divided traffic flow, to what Peters (2006) terms the organic flow in which various traffic participants are able to survive and co-exist aided by new kinds of communications regulating the overall system as a whole.

It is possible that smart-car technologies may accelerate the merging of 'personal vehicles' into 'virtual' territories that will allow them to be *intercepted* from external sources whereby material updates will be provided wirelessly from manufactures such as in-car software upgrades via car-to-dealer communications. Fundamental is the development of *telematics*, which includes wireless technology, vehicle tracking and navigation assistance, and car-to-car communications. Already 'Audi, BMW, DaimlerChrysler, Fiat, Renault and Volkswagen have formed the Car-2-Car Communications Consortium to seek consensus on standards for dedicated short range communication (DSRC)' (Bell, 2006, p. 148).

Longer-range communications will come in the form of satellite tracking, which in Europe will be provided by the Galileo system due to become operational in 2013. This system is based on a constellation of 30 satellites in constant communication with ground stations in order to provide information on vehicle location, real-time navigation, speed control, and potentially pay-as-you-go cost tracking. As part of the assemblage one would expect to see ground networks embedding vehicle transport into systemic communication infrastructures. Overall, this will include short range car-to-car communications merging with cellular and radio frequency identity (RFID) transponders interfacing with satellite and state transport data systems (see Bell, 2006).

Transport/social environments are increasingly converging into coded space such that external architectures become a form of 'software-sorted geography' (Graham, 2005). It is this availability of a pervasive computational mesh that makes intelligent infrastructure systems possible (Sharpe and Hodgson, 2006, p. 10).

4.4. Deprivatisation

The pattern of 'public mobility', of the dominance of buses, trains, coaches, and ships, will not be re-established on a large-scale (except in certain city-states like Singapore). It has been lost because of the self-expanding character of the car system that has produced and necessitated individualised mobility based upon instantaneous time, fragmentation, and flexibility. However, significant moves are taking place to *deprivatise* cars through car-sharing, cooperative car clubs, and smart car-hire schemes (Hawken et al., 2002; Shaheen and Cohen, 2007). By 2001, 600 cities in Europe had developed car-sharing schemes involving 50,000 people (Cervero, 2001). Prototype examples were developed in La Rochelle (Liselec), France; northern California; Berlin; and Japan (Motavalli, 2000, p. 233). Oxford has the UK's first hire-by-the-hour car club scheme, named Avis CARvenience. There are various other car clubs operating in the UK such as CityCarClub, Car Plus, and Carshare. Two US car-sharing companies are Flexcar and Zipcar. Canada has such coops as Communauto in Montreal and Co-operative Auto Network in Vancouver. Overall it is calculated that worldwide some 348,000 people share some 11,700 vehicles, with 60% in Europe (Shaheen and Cohen, 2007, p. 1). Increasingly this involves smart-card technology to book and pay and also to pay fares on public transport.

These developments reflect the general shift in contemporary economies from ownership to access, as reflected in the delivery of many services on the internet (Rifkin, 2000). One could hypothesise that payment for 'access' to travel/mobility services will supersede the owning of vehicles outright. One important consequence is that if 'personal vehicles' are not domestically owned, then the various coops or corporations that provide 'car services' would undertake short-term parking and especially the long-term disposal of 'dead' vehicles. The former would significantly reduce the scale of car parking needed since vehicles would be more 'on the road', while the latter would radically improve recycling rates (Hawken et al., 2002). Overall it is possible to expect a shift from 'cars' owned and driven by individuals, to deprivatised vehicles either owned by cooperatives or by corporations and 'leased'.

4.5. Transport governance

Except with regard to air travel, there is a noticeable shift away from predict-and-provide models, which were based on governments predicting traffic growth, then providing for it, and the growth then occurring, towards new schemes increasingly embedded within the emerging discourses of digitisation, sustainability, and security (see Vigar, 2002). 'New realist' policies involve many organisations developing alternative mobilities through integrated public transport, better facilities for cyclists and pedestrians, advanced traffic management, better use of land-use planning, real-time information systems, and a wider analysis of how transport impacts upon the environment (Vigar, 2002). In particular, 'western' transport policies increasingly take note of alternative models of transport governance as for example, in Curitiba, Brazil, Guatemala City, Pune, India, Bangkok, Santiago, and Lagos (Transport-Innovator, 2007). Such developments may ease some of the inner-city heavy traffic as car drivers will be encouraged to use these modernised and efficient bus services alongside other multi-modal forms of city transport such as connecting trams and metro. The city of London, UK is already investing in a new fleet of energy-efficient buses, including several hydrogen powered buses, in part paid for through congestion charging. These developments should foster increasingly efficient transport networks within high-density city areas and increased use of multiple forms of interconnecting public transport.

Thus, I have set out a number of small changes, in fuel systems, in vehicle body materials, in digitisation and in modes of governance. In the final section, I return to whether this multi-level set of changes could usher in system change and not just the further extension and elaboration of the current car system.

5. Futures

I have shown how the power of automobility is the consequence of its system characteristics. Unlike the bus or train system it is a way of life, an entire culture (Miller, 2000). It has redefined movement, pleasure and emotion in the contemporary world. Sheller emphasises 'the full power of automotive emotions that shape our bodies, homes and nations' (Sheller, 2004, p. 237; Gilroy, 2000). The car system possesses distinct characteristics. It changes and adapts as it spreads along the paths and roads of each society, moving from luxury, to household, to individual item. It draws in many aspects of its environment which are then reconstituted as components of its system; the car system became central to and locked in with the leading economic sectors and social patterns of 20th century capitalism. It changes the environment for all the other systems. It promotes convenience rather than speed; the car system is a key component in the shift from clock to instantaneous time. It seems to provide the solution to the problems of congestion that it itself generates. It is able to externalise dangers onto those outside the system as it provides enhanced security for those within it. And it is central to the individualist, consumerist culture of contemporary capitalism.

Yet the days of 'steel-and-petroleum' automobility are surely numbered. In the next few decades, it is unlikely that individualised mobility will continue to be based upon the 19th century technologies of steel bodied cars and petroleum engines. A tipping or turning point will occur during the 21st century when the 'steel-and-petroleum' car system will be seen as a dinosaur (a bit like the Soviet empire, early PCs or immobile phones). When such a tipping point will occur cannot be at all easily predicted, let alone subject to 'governance' since it is fundamentally a multi-level process. According to Geels (2006, p. 166), system changes of

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this sort have a number of characteristics: co-evolution of numerous interrelated elements; changes in both demand *and* supply sides; a large range of actor implicated; long-term processes stretching over decades; and the sheer impossibility of change being brought about by single 'policy' as such.

Hence, system changes cannot be read off from linear changes in existing firms, technologies, practices, and governments. Just as the internet and the mobile phone came from outside the 'system', so the tipping point towards the 'post-car' will emerge unpredictably from an array of technologies or firms or governments not currently a centre of the car industry and culture, as with the Finnish toilet paper maker Nokia and the unexpected origins of the mobile phone that brought in a whole new system. It will develop in some place and suddenly it will be the fashion. It will probably emerge in a small society or city-state with very dense informational traffic that can convert into a post-car configuration (Iceland perhaps as an interesting prototype which has already announced itself as the first Hydrogen Society). And it will emerge out of crisis when the high carbon economy/society *has* to be massively restructured, as Klein (2007) describes in her recent analysis of 'disaster capitalism'. It is particularly likely to emerge when the 'speed and violence' of 'global heating' can no longer be resisted because of the tipping points towards almost irreversible climate change (see Pearce, 2007).

The escalating impact of global warming means that many extensive mobility and communication connections that straddle the world begin to collapse and there is increasing separation between different regions or 'tribes'. Systems of repair begin to dissolve and there is localised recycling of bikes, cars, trucks, and phone systems. More generally there would be a plummeting standard of living, a relocalisation of mobility patterns, an increasing emphasis upon local warlords controlling recycled forms of mobility and weaponry, and relatively weak national or international forms of governance. There will be increasing Hobbesian wars of each warlord-dominated region against their neighbours especially for access to water, oil, and gas. And with extensive flooding, extreme weather events, and the break-up of long distance oil and gas pipelines, these resources become exceptionally contested and protected by armed gangs. There have of course already been various oil wars and the heated planet will also usher in water wars. Those who can live in gated encampments will do so.

This set of developments might *just* provoke a 'disaster capitalism' that produces a new system that goes beyond the 'steel-and-petroleum' car. This will only be feasible if large prospective profits can be generated for private corporations. There is no necessary correspondence between what the market will produce and what would be in long-term planetary interests; as Stern (2006) notes climate change is the greatest of all market failures.

What then might develop if the global crisis becomes so 'disastrous' that there seems no alternative, not to 'improving' the car but to innovating a whole new 'post-car' system? Commencing in some societies in the rich 'north' this alternative scenario would consist of the following: there would be multiple, dense forms of movement mainly of small, ultra-light, smart, probably battery, biofuel, or hydrogen-based, deprivatised 'vehicles'. Flexibilised travelling would involve accessing such small, light mobile pods as and when required. Electronic regulators embedded in lampposts and in vehicles would regulate access, organise price, and control the vehicle speed. Some such vehicles would be driverless. The movement of vehicles would be electronically and physically integrated with other forms of mobility both informationally and physically. 'Traffic' would consist of a mixed flow of slow-moving semi-public micro-cars, bikes, hybrid vehicles, pedestrians, and mass transport and these would be 'integrated' into networks of physical *and* virtual access. There would be electronic coordination between motorised and non-motorised transport and between those 'on the move' in many different ways. Smart 'cards' probably embedded in mobile phones would control access to and pay for people's use of the various forms of mobility (and probably much else besides). And software systems will 'intelligently' work out the best means of doing tasks, meeting up or getting to some place or event. Simultaneously neighbourhoods will foster 'access by proximity' through denser living patterns and integrated land use. People will live in denser, much more integrated urban areas that maximise co-presence. Such redesign would 'force' people to bump into each other since their networks will overlap. This scenario would involve carbon allowances as the new currency that is allocated, monitored, and individually measured so regulating much physical mobility. Some of the time physical travel would be replaced by modes of virtual access which will increasingly simulate many of the affordances of physical co-presence.

Whatever any new system will be like, it will substantially involve a focus upon the individualised and flexible movement that automobility has brought into being during the 'century of the car' (Gilroy, 2000). I have examined post-car mobilities, or life beyond the car, as an assemblage system shift, knowing how linear transitions do not generate major social and lifestyle upheavals. In this way, such future(s) contain their own unpredictability. Knowing when and from where that all important tipping point may occur is elusive. Only when it begins to emerge will it become clear what Mumford (1953, p. 10) meant decades ago when saying that: 'the only cure for this disease is to rebuild the whole transportation network on a new model'. And it is likely that only a new form of 'disaster capitalism' when global heating and oil shortages are so clearly productive of global catastrophe that a new round of capitalist restructuring will be engendered that will seek to save human life on the planet by going beyond the current car system.

But even if this is achieved along the lines of what I have suggested there is no free lunch here, no way of reorganising governance without cost. This potential nexus system entails a 'digital panopticon' involving satellite tracking; ubiquitous CCTV cameras; data mining software; the migration of systems of biometric security into urban areas; the increasing distribution of the 'self' across various databases; more general database-isation to integrate most elements of a person's economic, social, and political life; the standardisation of space; the embedding of digital processing within the environment; the location of sensors within moving vehicles to operate smartly; technologies that track the position of objects and people; automated software systems for allocating road space; smart code space that will come to determine the route, price, access, and speed of vehicles; sensors and processors that enable vehicles to self-navigate; and the likely tracking and tracing of each person's carbon allowances and carbon expenditures. These systems of tracking and tracing surveillance involve step changes taking place in the character of life. In order to move around there is a Faustian bargain to be struck, and especially significant is that the car will only be superseded through a nexus system that orders, regulates, tracks, and may within a few decades drive each vehicle.

So there are two stark futures. On one hand, there is the barbarism of unregulated climate change, increased flooding, and extreme weather events, the elimination of many existing 'civilizing' practices of economic and social life, and the dramatic collapse of long range mobility and related developments of the past decades, with New Orleans surely even more iconic of the future of the 'west' than September 11. Life even in the 'west' will be nasty, brutish, and almost certainly 'shorter'. But then it might be just possible to avoid this if a whole gamut of transformations takes place—but this involves a digital Orwell-isation of self and society, with more or less no movement without digital tracing and tracking and with no-one beyond the panopticon. This may tame the car system (and other energy systems) if many other developments take place simultaneously such as the tracking each person's carbon allowance, which in turn functions as the public measure of worth and status. It may be that global futures are poised between a Hobbesian or an Orwellian future (see Dennis and Urry, 2008, for much more detailed analysis).

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