Vehicle design and technology issues	Relevant Factors / Evidence	Some Implications
SUSTAINABILITY	Environmentalists warn that **current patterns of automobile production and use are unsustainable**, with pollution and congestion already at unacceptable levels in most major urban areas. Experts claim that **massive cost savings potential exists in current inefficient production and consumption systems –** via the more sensible and integrated deployment of known technologies and design techniques[1]. Achieving greater fuel efficiency is a major factor in vehicle design. Evidence is now growing that a "leapfrog" raising fuel economy of between 4 –10 times may be easier, cheaper, and strategically more advantageous than an incremental 3x gain[2]. In the UK, the **Foresight Vehicle** Initiative[3] aims to stimulate suppliers to develop and implement market driven technologies for future vehicles.	The challenge to develop technology options that form the basis of a sustainable transport policy is a formidable one. Develop "cleaner" vehicles which will reduce or eliminate pollution. Provide intelligence to avoid occasions of high pollution and fuel consumption: slow-moving traffic and gridlock. Develop personal and corporate mobility management strategies. Develop more energy efficient vehicles to make the best use of limited fuel resources Produce safer vehicles. Enable vehicles to communicate with other vehicles and the infrastructure to make better use of existing roads, particularly as infrastructure nears capacity. Consumer wants are often in conflict with environmental objectives and social change is slow. Increasingly, essential and priority services may have to be prescribed in regulations and given priority. A combination of government environmental regulations, fiscal measures and a wider appreciation of consumer needs, will be required in order to properly translate the current Ford Motor Company slogan "Everything we do is driven by you".
VEHICLE DESIGN	Vehicle weight, material composition and aerodynamic shape are important considerations in vehicle design.	Future vehicles are likely to require: • increased automation to help drivers cope with increased traffic densities • means of communication to allow drivers to make better informed decisions • means of reduction of energy use and pollution • active safety features particularly for lightweight vehicles • new product design tools to reduce the cost and increase the rate of new product introduction
Weight	**Weight has a major effect on vehicle fuel consumption**. Up to 40% of fuel consumption is attributable to vehicle inertia weight losses. During the 1990's the trend towards increasing comfort and refinement features together with enhanced safety standards have led to an overall increases in vehicle weights.	Weight reduction must be achieved without sacrificing handling, performance, reliability, passenger comfort and safety. Need to increase recyclability Lightweight vehicle design, while presenting new challenges, does not preclude crashworthiness.
Materials & Structures/ Hypercars	**"Lightweighting"** can be achieved by using lighter materials – e.g. metals such as aluminium and magnesium or composite materials.	Cost of aluminium and magnesium need to be reduced. Implications for a wide range of industries-notably cars, oil, steel, and

Vehicle design and technology issues	Relevant Factors/ Evidence	Some Implications
	Composites offer advantages in both vehicle design and production. High specific material strength and stiffness, along with very high fatigue resistance, allow significantly reduced mass while maintaining or even improving component strength and durability and vehicle stiffness. **Optimised steel technology** could reduce body weight by up to 215%, and aluminium could reach 40%, but **carbon fibre** composites could save as much as 50-67%[4]. The use of **plastics** is increasing rapidly in vehicle manufacture. The Audi A2 is an affordable mass- produced aluminium vehicle – the body weight is only 67% of the customary steel structure[5]. Chrysler's Concept vehicle[6] demonstrates the possibility of producing an **affordable lightweight recyclable composite car**. The estimated urban fuel economy is 50mpg and the thermoplastic body sections are completely recyclable. The latest research is on **"Hypercars"** with 3-5 times better fuel efficiency, virtually no emissions and technologies that are almost completely recyclable or reusable[7]. Depending on design details, mature ultra light-hybrid hyper-cars could achieve 60-120 km/l using virtually any fluid fuel, perhaps ultimately up to 250 km/l with fuel cells, while being safer, more comfortable and durable, cleaner and probably cheaper than today's cars. Momentum transfer places severe demands on the crashworthiness of an ultra light car colliding with a heavy one. But advanced composites in the right shape can absorb up to 5x as much energy/kg as steel; materials and design are more important to safety than is mere mass; and what it takes to protect people needn't weigh much. Other ideas include making vehicles smaller (e.g man-wide car), more versatile during their lifetimes (upgraded to cope with disabled or older users), and dual-mode, enabling it to alternate between guided and unguided transport.	electricity-could be profound. For composite cars there are still some hurdles to be overcome. Composite cars cost less to manufacturer than a conventional car as they have far fewer parts/components and take less time to assemble. However the manufacturing process for composite cars is complex. Car makers should in the future be able to combine hybrid-electric drive with lightweight, low-drag platform design to produce hyper-cars which are efficient, produce low or zero emissions, provide excellent performance and safety and are saleable at a profit. They claim the barriers to such progress are more cultural than technical or economic. However, hypercars cannot solve the problem of too many people driving too many km in too many cars, and could make it worse by making driving more attractive and its marginal cost approach zero.
Smart tyres	Goodyear is developing **tyres** that automatically measure inflation pressure, temperature and excessive tread life. Sensors will be able to ward drivers before tyres go flat or when they need more air. Future tyres will be able to distinguish between dry, wet and icy roads.	
Drag/rolling resistance	**Reducing a car's drag** can also improve performance and efficiency. Compared to conventional cars, aerodynamic drag can be reduced by more than 40% with design methods such as a smooth underbody, a tapered rear end, minimised body seams, and aerodynamically designed air intakes etc. **Rolling resistance** can be reduced by more than 50% by incorporating ultra lightweight	Refine existing design guidelines. Regulatory measures and/or fiscal incentives to encourage manufacturers to improve car design.

Vehicle design and technology issues	**Relevant Factors/ Evidence**	**Some Implications**
	design and low-rolling resistance tyres, wheel bearing and brakes.	
Accessories/Integrated electronics	The **energy consumption of accessories** is often overlooked but becomes important at low tractive loads. Typical car air conditioning has the same cooling capacity as a house! Integrated electronics are an essential component of the hypercar - including the component controllers, sensors, switches, and actuators.	By implementing a design that allows for upgrading, more communication between components, and smart switches and sensors, new sophisticated functions can be added via software rather than hardware and hence more cheaply.
ALTERNATIVE PROPULSION SYSTEMS	**These are discussed more fully in the Energy Fact sheet.** A variety of new power plants for personal vehicles have entered operation on a test basis; **hybrids** which use fuel cells and conventional batteries, and **alternatively fuelled vehicles. Exhaust energy recovery** systems and **regenerative braking** to recapture energy lost in deceleration can also play a part in improving engine efficiency.	
SMART CARS	Emerging transport telematics technologies offer many possibilities for improving vehicle control, comfort and safety. **Advanced Vehicle Control Systems** (AVCS) include any vehicle or road-based systems that provide increased safety and/or control to the driver. The unifying purpose is to **improve safety**, whether by aiding the driver in controlling the vehicle as with anti-lock braking (ABS), or by actually removing the driver from a hazardous environment, such as with autonomous military vehicles.	AVCS technologies are likely to become more sophisticated and less expensive as the costs of sensing, communication and computing power continue to fall. Likely to be continued growth in vehicle control and automation. Ultimately efficiency gains are expected to provide significant growth of road capacity and allow for more rapid and cheaper road construction and maintenance operations e.g. guided snowploughs, pavement crack and pot-hole sealers, roadside lawn-mowing machines, traffic cone laying machines etc. Many AVCS require no road infrastructure modifications. Driving public need to be prepared to pay for safety-related systems. AVCS systems need to be accurate to gain public support. More human factors research needed to determine how best to indicate the level of threat to the driver.
ABS/Traction control	**ABS** is well known; **traction control** systems also measure and reduce wheel slippage but under acceleration instead of braking. **Active suspension** systems vary the spring or damper rates to suit the prevailing driving conditions as indicated by **sensors** for wheel displacement, steering angle, vehicle speed and acceleration. **Vehicle stability** systems prevent cars from spinning out when driven too fast around bends.	
Intelligent cruise control	**Autonomous Intelligent Cruise Control** monitors the distance to the vehicle ahead, and actively slows the subject vehicle (warn driver, apply brakes, reduce throttle and/or downshift transmission) if danger is "sensed" ahead.	
Collision warning	**In-vehicle collision warning** systems warn of hazards around the vehicle. Radar is typically used to monitor ahead, but also side-viewing radars or CCD	

Vehicle design and technology issues	**Relevant Factors / Evidence**	**Some Implications**
	cameras monitor blind spots and warn the driver if it is not safe to change lanes. Several Japanese-market cars and trucks are equipped with such systems. In the near future collision avoidance systems may automatically take corrective actions if the driver does not.	
Vision enhancement	**Vision enhancement** systems improve the visibility of road hazards at night or in bad weather using IR and UV illumination techniques. Current technology is too expensive for general use. Texas Instruments Nightdriver allows drivers to see 3-5 times the distance in front of their headlights.	
Lateral control	**Lane Following and Maintaining** methods rely on vehicle-based cameras to monitor the road ahead using lane recognition algorithms. The system gives an audible signal when the vehicle starts to drift from its lane or automatically centres the steering in the lane.	
Driver monitoring	**Driver monitoring systems** measure the state of the driver by monitoring steering wheel movements, and/or eye blinking using image processing. The system emits a warning signal if detects that the driver is falling asleep or otherwise incapacitated.	
Enabling technologies	Sensor technologies include **imaging methods** (radar, laser, sound wave propagation, thermal, video imaging), **triangulation methods** (e.g. GPS), **trail-following methods** (e.g. OBahn guided buses), and **dead reckoning** systems (e.g. radio beacons). Ultimately an AVCS must activate either the steering, propulsion or braking systems. The latest developments are "**drive-by-wire**" systems which allow consolidation of idle speed control, cruise control, traction control and manual throttle control to a single actuator. **Electronic licence plates** (ELPs) have electronics and an antenna embedded within. The next generation will tie into the vehicle electronics system and offer 2-way communications. All vehicles within a large area could be equipped with ELPs, given state intervention in licensing, and thus interoperable vehicle-vehicle communications becomes possible much more quickly than waiting for the vehicle fleet to renew.	Public acceptability, especially privacy will be an issue. Systems need to be robust to deter fraud, and resist accidental damage or deliberate vandalism. Drive-by-wire systems have technical advantages over mechanical systems, but flexibility is the greatest benefit since the electrical interface allows easy system upgrades.
SMART HIGHWAYS	An **automated highway system** (AHS) is a lane, or set of **lanes where specially equipped cars, trucks and buses could travel together under computer control.** The long range goal of AHS is to significantly improve the safety and efficiency of the transport system[8]. Some estimates show an up to 80% improvement in travel safety and a doubling or tripling of lane capacity. AHS also offers the potential for substantial improvements in trip predictability, level of service, inclement weather operation, mobility and air quality	**Automation of highways is technically feasible,** even with existing technology[11]. It is no longer economically or environmentally feasible to extend the road infrastructure on a large scale. Significant breakthroughs in future performance of the vehicle/highway system may be fundamentally dependent on the application of automated vehicle

Vehicle design and technology issues	Relevant Factors / Evidence	Some Implications
	level of service, inclement weather operation, mobility and air quality. Two distinct types of automated highway are possible. The first is a **dedicated lane** system, in which certain lanes are reserved for automated vehicles. The second is a **mixed traffic** system: fully automated vehicles would share the road with partially automated or manually driven cars. Organisation of traffic on automated highways could range from **free-agent vehicles to platoons**. Free-agent vehicles operate independently and each would drive so that it would be able to stop without mishap even if the vehicle ahead applied maximum braking. Platooned vehicles, at the other extreme, would operate in closely co-ordinated groups to **maximise highway capacity**. The PATH Program[9] has developed the technology whereby magnets buried at intervals in the roadbed would be sensed by magnetometers in vehicles, providing a way to monitor their location and speed. In Japan, the **Advanced Cruise Assist Highway System** is well advanced. The first stage involves informing drivers, taking partial control - crash avoidance for longitudinal obstacles - and controlling steering for lane keeping or collision avoidance. In Europe **CHAFFEUR**[10] is addressing **truck platooning** which aims to develop a virtual electronic linkage amongst several heavy goods vehicles in convoy with a single driver. Such systems could be in operation by 2010 thus opening the way to "**HGV trains**" **Urban Drive Control** (UDC) is a project which has been tested in Turin to enhance traffic flow in cities to reduce pollution. Road beacons are used to calculate the favourable speed to improve traffic mobility which is then recommended to drivers or imposed automatically.	control technology. Future scenarios will need to keep the division between cars and infrastructure in mind – unlikely to have systems comprised entirely of automated cars nor entirely infrastructure based systems. Road-vehicle co-operation will be required. Evolution from manual to full automated control may transition through stages of control assistance, partial control and eventual full control. Initial deployment and operation is expected to focus on high priority routes located in high demand, major urban and inter-city corridors. A dedicated lane system would require more extensive physical modifications to existing highways but it promises the greatest gains in highway capacity. AHS could allocate priority to different classes of road users where demand exceeds supply. Secure communication systems will be needed to ensure safety-critical messages can be transmitted quickly and reliably, and that will identify the transmitting vehicle unambiguously. Human interfaces with in-vehicle terminals present new and relatively unique challenges. Need to consider fail safe AHS, disaster prevention and the means of recovery from system failure. AHS concepts which centre around dedicated, highly structured driving environments to gain large efficiency gains will require sophisticated control systems and significant vehicle-infrastructure adaptations to operate. Cost of additional equipment for automation may not prove prohibitive because new cars slowly acquire most of the needed electronics anyway. Need an effective organisation and framework to co-ordinate AHS effort. How willing will car manufacturers be to accept the potential liabilities involved in selling cars that drive themselves.
Traveller Information Services	Uncertainty is one of the major problems when travelling. Advanced in-vehicle driver information and route guidance systems can notify drivers of hazardous road conditions, suggest optimum routing, guide drivers to vacant parking spaces or perhaps automatically summon assistance during emergencies. Indeed the ON-Star[12] navigation offered by GM and RESCU of FORD boast such features now. The release of airbags triggers an emergency signal picked up by a central station, which then alerts the emergency services. Within a few years, navigation systems will be able to incorporate data on **real-time traffic conditions** and adapt the preferred route accordingly. This system	By providing more information, it is hoped that travellers will adjust their time, route or mode to their own advantage, which will also improve intermodal transport system efficiency. High quality information systems are recognised as being among the most important systems likely to have a direct influence on the modal choice of travellers. Indeed, investing in good information systems sometimes leads to sizeable increases in public transport patronage or at least the continued loyalty of passengers.

Vehicle design and technology issues	Relevant Factors/ Evidence	Some Implications
	may incorporate GPS antennas and receivers, LCD panels, Compact Disk -Read Only Memory/ Digital Video Disk (CD ROM/DVD) players, communications hardware, driver interface units, map databases, and route optimisation programmes. **Voice recognition** for various functions will minimise problems caused by driver inattention resulting from distraction or other factors. Microsoft is showing interest in the automobile industry in the **Auto PC** Platform. Auto PC takes the form of a sophisticated car radio featuring a voice recognition system which means the radio, telephone and on-board navigation system can all be voice controlled. Such developments will enable the car to become a **mobile office**.	Need to integrate various traveller information systems in to a single in-car unit to avoid overloading users with information, competing demands or conflicting advice. Human-machine interface needs more investigation to ensure that systems are well adapted to user needs and do not compromise road safety. Work is required to develop **diversion strategies** that will not simply divert the congestion elsewhere particularly to unsuitable routes. Main obstacles to large scale deployment of telematics are lack of institutional and regulatory framework, lack of harmonisation/standardisation of equipment and lack of funding Potential for everyone to be an expert traveller, completely informed pre-trip and on-trip on the options for the journey ahead
NOVEL INFRASTRUCTURE OPTIONS	These are discussed in more detail in the Emerging concepts and technologies Factsheet.	Environmental costs are likely to increase substantially as concern about the environment grows (e.g. M3 at Twyford Down, Newbury Bypass) More thought needs to be given to including the "value" of habitats, social amenities, landscapes and other external goods in the cost-benefit equation.
Tunnels	The inherent difficulties in extending infrastructure above ground, raises questions about the **greater use of tunnels** for increasing network capacity[13]. Significant advances in tunnel technology and inclusion of all costs (in terms of delays, police and private security, damage to the environment, quality of life) in scheme appraisal might make tunnels more competitive.	Scope for a more strategic pro-active vision of tunnels. Placing infrastructure underground brings with it its own safety considerations – fire hazard, ventilation, escape routes, emergency access routes etc.
Tube freight	**Tube freight transport** is an unmanned system in which close-fitting capsules or trains of capsules carry containerised freight through tubes between terminals. If this system were implemented in congested areas, passenger vehicles could be separated from freight vehicles with improvements in efficiency and safety for both modes.	Tube freight transportation is a promising concept but considerable resources would be required to develop even a prototype system. Tube freight systems can carry high-volume freight into highly congested areas with minimum effect on surface transport systems. Tube freight systems would need to integrate with more conventional distribution systems at collection distribution hubs.
MAGLEV	**MAGLEV** systems offer opportunities for improved passenger and freight transport either above or underground. Magnetic forces lift, propel and guide a vehicle over a specially designed guideway and cruising speeds of 300 mph or more are possible. The first Maglev project in the US could be operating in revenue service by 2010 if funds are appropriated[14]. The Swiss are developing a **Maglev tube transportation system**[15]. The prime motive is to obtain the benefits of a high-speed passenger system in a region where there are **major environmental constraints.**	Maglev could provide high speed ground transport services. Competition with air would intensify. However Maglev services could also generate new traffic, given the shorter travel times, say between major cities. Tube transportation reduces tunnelling costs by reducing tunnel diameter.

Other relevant factsheets

Energy issues

Environmental concerns

Emerging concepts and technologies

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