The Automotive Industry

...the future guide

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Content

Glossary

ACEA	Association des Constructeurs Européens d'Automobiles = the European vehicle manufacturers' representative body, based in Brussels
CAIR	Centre for Automotive Industry Research at Cardiff University, Wales, UK
CNG	compressed natural gas
CO2	strictly CO_2 ; carbon dioxide
CVT	continuously variable transmission; nowadays used to refer to belt or chain-driven types of step-less automatic transmission
ELV	end of life vehicle
EU	European Union
FDI	foreign direct investment
IC	internal combustion engine (petrol and diesel primarily; though also LPG and CNG-powered variants)
IVT	infinitely variable transmission as in the British Torotrak transmission
LNG	liquid natural gas
LPG	liquid or liquefied petroleum gas
MFR	micro-factory retailing: a future car making model proposed by CAIR, which features small localised sites which combine assembly with retailing and aftermarket activities
PDI	pre-delivery inspection
SMMT	Society of Motor Manufacturers and Traders; the UK vehicle manufacturers, importers and associated industries representative body
ULSAB	Ultra-Light Steel AutoBody; an international programme supported by 33 steel makers to show that steel can be used to meet future car weight reduction requirements.
ZEV	Zero Emissions Vehicle, as defined under the California Air Resources Board ZEV Mandate

Introduction

The car industry today consists of a number of large global vehicle manufacturers operating a series of large centralised assembly plants. These source around 60% to 70% of the value of their products from independent suppliers with their own dispersed manufacturing networks. The vehicle manufacturers send their products for distribution around the world to networks of small local retail dealerships that operate on the basis of an exclusive 'franchise' system. We analysed this, the current state of the industry, in a previous BT-CAIR publication: ***The Automotive Industry - A Guide***[1].

The automotive industry is standing on the threshold of dramatic and enduring changes. In this booklet we will explore the forces bringing about such change in the industry, set against those that resist change. We consider in what directions such change might lead the sector and we will explore what sort of cars a future industry might make. We consider new technologies, new materials, alternative fuels, new types of motive power and the advent of telematics. It is likely that the very concept of automobility will be transformed over the next few decades.

The Industry Today

The automotive industry today is already under severe pressure and it has, in many respects, reinvented itself over the last 10-15 years. There are two key pressures:

- **Economic pressures, particularly the problem of maintaining profitability**
- **Environmental pressures and the broader issues of corporate social responsibility**

These pressures revolve around the characteristics of the product (an all-steel vehicle with an internal combustion engine) and of the production process needed to make a product of that design (pressing, welding, painting, machining, assembly with short cycle times). This product-production configuration has been termed Buddism after Edward Budd, inventor of the all-steel welded body. To understand how the industry has come to this position it is very helpful to analyse its history ***(see opposite)***.

A short history of mass car production

The question arises why the car industry has to produce individual models in high volumes in the first place. To understand this we need to analyse history. Henry Ford is normally credited with introducing mass production to the car industry. He built his first car in 1899, but his real break came with the Model T, or 'Tin Lizzie'. This car was introduced in 1908 and was built in the then conventional fashion on a separate chassis, fitted with composite (ash-frame with metal panels) - largely outsourced - bodies. Ford's mass production techniques focussed primarily on process improvements; streamlining the machining of key mechanical components and their assembly into a chassis. These improvements were gradually adapted to producing the Model T and incorporated into its production system. The moving assembly line, for example, was introduced in 1913.

Observers have commented that Ford managed to make many variants of the Model T, even though the term 'mass production' implied standardised output. The answer to this apparent anomaly is that Ford did not make cars as we know them today. He adapted mass production from the gun and meat processing sectors to the making of a pre-industrial design of vehicle. That is, the Model T was a design essentially derived from the coachbuilt tradition with a separate wood-frame body on a separate chassis that carried all mechanical components. The modular nature of the separate chassis and body construction meant that a range of different bodies could be offered on the same chassis. Stretching the chassis for long wheelbase variants was also a simple process involving the welding in of inserts and adding a longer propshaft.

So, how relevant is this for modern car making? Well, to some extent; many of Ford's approaches to process are still relevant today. For example, Ford really instituted the concept of breaking down the assembly process into many small stages, each of which could be undertaken by a relatively unskilled worker. The concept could only work if accurate parts were supplied to the point of assembly. The concept of repeated short-cycle tasks was developed further by the 'time and motion' expert Taylor. However, the key technology elements of a modern car plant have moved beyond efficient casting and machining of mechanical components. Ford outsourced most of his bodies, yet a modern assembly plant consists largely of the means to make and paint steel car bodies developed by Edward Budd and using the following key processes:

- **Press Shop:** where steel sheet is cut into blanks which are pressed into body panels
- **Body Shop:** where these panels are welded into a three-dimensional box-like structure, the steel monocoque or unibody, which fulfils the functions of both chassis and body, at this stage known as the body-in-white (BIW)
- **Paint Shop:** where the BIW is painted
- **Final Assembly:** where the mechanical, electrical, electronic and all other elements are fitted into the painted body to make a complete car.

Apart from final assembly, all the main elements of a contemporary car plant are there to support the use of what we call 'Buddist' technology (named after Edward Budd, see page 8.). These are involved in the manufacturing of the all-steel body.

Economic pressures

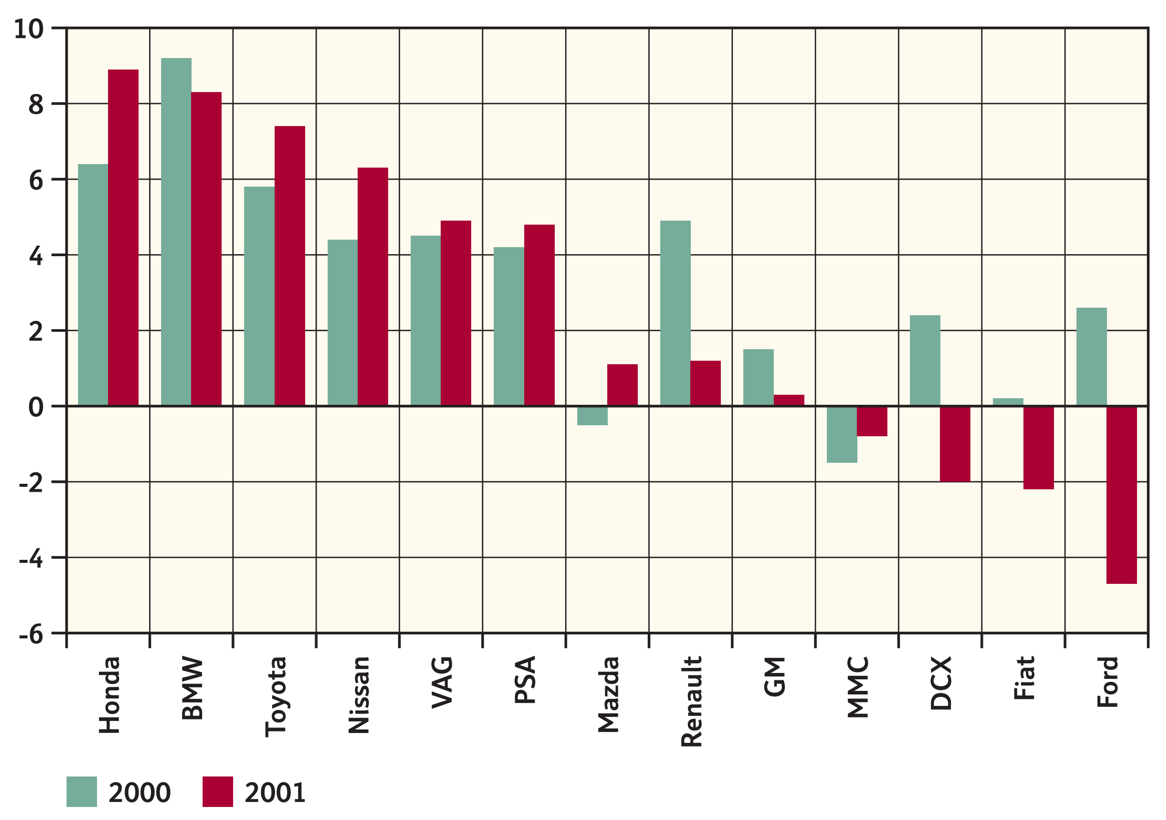
Recent years have been witness to a surge in mergers and acquisitions in the automotive industry. Although few brands actually disappear (notable casualties include Oldsmobile and Plymouth in recent years) and some long-moribund brands are even revived (e.g. Bugatti, Spyker and Maybach), there are fewer and fewer independent vehicle manufacturers. The industry has become characterised by global constellations manufacturing vehicles under a number of brand names via a number of divisions. Increased scale is seen as the only means to survive economic pressures.

Multi-brand constellations: *some examples*

General Motors:	Chevrolet, Pontiac, Buick, Cadillac, Saturn, GMC, Holden, Opel, Vauxhall, Isuzu, Saab, Daewoo; linked with: Fiat: Fiat, Alfa Romeo, Lancia, Ferrari, Maserati
Ford:	Ford, Mercury, Lincoln, Jaguar, Volvo, Land Rover, Aston Martin, Th!nk; linked with: Mazda
VAG:	Volkswagen, Audi, Skoda, SEAT, Bentley, Lamborghini, Bugatti
DaimlerChrysler:	Mercedes-Benz, Chrysler, Dodge, Smart, Mitsubishi; linked with Hyundai: Hyundai, Kia, Asia

The fact is that car making is not a very profitable business. This may seem surprising when you consider some newspaper headlines reporting multi-million dollar profits, but these merely reflect the scale of the industry. The turnovers or sales of the big players are massive, but the profit margins on these large turnovers are wafer-thin. Even the most profitable car makers rarely exceed a 5% return on sales or a 15% return on investment. In fact the car industry is chronically unprofitable. The profits made in the boom years at the top of the economic cycle are used for research and product development, and to sustain companies through the lean years that inevitably follow. ***Figure 1.*** gives some data on profitability.

Figure 1. Profit Margins Principal Car Makers 2000 and 2001%



Underpinning the economic pressures on profitability is the fundamental issue of supply and demand. In essence, growth rates, in the established markets of the world have been relatively low, while 'emerging' markets such as India and China have been slow to emerge. As a consequence there is a greater capacity to supply the market than there is demand for product. This in turn tends to result in over-supply that in turn drives down market prices. Hence, physical productivity can be negated when it results in over-supply, as no benefit accrues from making product efficiently which can then not be sold. ***Figure 2.*** illustrates productivity in Europe's leading car plants.

Figure 2. European Car Plant Productivity

Manufacturer	Plant	Country	Output (2001)	Output per employee
Nissan	Sunderland	UK	296,489	95
Ford	Saarlouis	Germany	408,405	87
Toyota	Burnaston	UK	156,000	87
Fiat	Melfi	Italy	350,756	82
GM	Eisenach	Germany	137,272	77
Renault	Valladolid	Spain	277,188	77
GM	Antwerp	Belgium	313,722	76
GM	Zaragoza	Spain	358,040	75
Renault	Flins	France	376,396	73
Ford	Valencia	Spain	318,423	70

(Source: WMRC, 2001)

Environmental pressures

There is also a new set of problems. The environmental impact of the car is increasingly a cause for social and political concern. Legislation and social pressures to limit the intrusion of cars are making life more difficult and more expensive than ever for the vehicle manufacturers. There has been a long-term process of change under which the definition of 'prejudicial to human health' has become broader in its interpretation.

This process of regulation started with emissions limits and safety requirements. Over time, those emissions limits have become more stringent or more demanding to meet. Equally, safety standards have developed from the requirement to fit basic items of equipment such as seatbelts, to meeting various impact criteria affecting the whole vehicle structure. Again, over time the equipment fitted has grown, while the impact requirements have become more demanding. Regulators are now considering pedestrian and cyclist safety during impacts with vehicles. The process of vehicle manufacturing itself is also increasingly regulated, with particular reference to volatile emissions to the air from the paint shop, and water pollution.

With the introduction of End of Life Vehicle (ELV) legislation in Europe the vehicle manufacturers will also become responsible for vehicle disposal and recycling.

Strategic responses

We find therefore that the current way of making and using cars is neither economically nor environmentally **sustainable**.

Given that they have these problems, what are the car manufacturers doing about it? The automotive industry has devised several strategies intended to tackle some of the problems:

- **Reducing costs by moving to lean production;**
- **Trying to recapture economies of scale lost in product diversification via globalisation, mergers and acquisitions, and multi-brand platform strategies;**
- **Shifting fixed costs through vertical disintegration; and**
- **Squeezing bought in costs by putting pressure on suppliers.**

Lean production became a buzzword in the industry during the 1990s. It is based on the Toyota Production System, developed in Japan and inspired by - among other influences - an American called Deming who introduced quantitative quality control. It makes car making more efficient through the elimination of waste in the widest sense and measures these improvements. It was popularised in the book ***The Machine that Changed the World***[2].

Globalisation and the creation of multi-brand platforms have become the standard industry response to the need to recapture economies of scale. It is not a panacea, not least because markets can become resistant to such strategies if genuine differentiation is lost. In such instances brand values become so insubstantial as to lose their meaning. Still, this approach has become important.

Vertical disintegration has accompanied the introduction of lean production, and it allows the vehicle manufacturers to reduce fixed costs. This gives greater flexibility; and the discipline of market forces on the external supplier can drive up efficiency. However, there remains the strategic issue of whether an activity or operation is considered 'core' to the business of making cars. Different vehicle manufacturers have different views on this matter.

Where all manufacturers appear to agree is that squeezing costs out of suppliers is a valid strategy. However, there are some signs that this strategy is reaching its limits. First, suppliers are themselves refusing to work with various vehicle manufacturers: in 2002 Michelin announced that it would not supply GM in Europe for example. In other cases there have been spectacular business failures (Federal Mogul is a good example) such that vehicle manufacturers and first tier suppliers have now been forced to establish special business rescue teams.

Budd

Edward Budd set about developing the all-steel body with his associate Joe Ledwinka around 1912 in Philadelphia with most early patents dating to 1913 - the same year as Ford's moving assembly line. There was one issue more than any other that prompted this move: the painting of vehicle bodies. In particular, the paint drying process was the single largest bottleneck in car production at this time. Early attempts to heat painted bodies in order to dry them caused many to catch fire. Some colours could take weeks to dry. Dodge Brothers were the first to put their faith in Budd's technology on a large scale, ordering 5,000 bodies from Budd in 1914 and 50,000 in 1915. Within two decades this technology dominated car making.

The main investment cost of a contemporary car plant is in the technology needed to make the all-steel body. The typical costs of these pieces of Budd technology are outlined in ***Figure 3***. Note the costs exclude land, a significant element in many locations given that a car plant occupies a large, flat area that must have access to the full range of infrastructure services.

Figure 3. Typical Plant Investment in Budd Technology

Production phase/process	Typical investment cost (£)
Press Shop	100 million
Press Tooling per car model	20 million - 65 million
Body-in-White	50 million - 100 million
Paint Plant	200 million - 250 million
Total	370 million - 515 million

(Source: CAIR)

Around 75% of the total investment in car plants is directly related to making and painting the all-steel body. These are effectively the entry costs to modern mass car making and they mean that on average 2/3 of the cost of a new car is for the factory that builds it. Although precise amounts depend on planned capacity and levels of automation, this is the amount a manufacturer needs to spend before he has built one car. The press tooling is dedicated to a specific model or variant and needs to be spent for each model in the range. Each new model generation - introduced roughly every 4 to 8 years - requires this investment again. It is paying back and maintaining such investments that determine economies of scale in mass car production.

Budd - continued

Citroën was the first in Europe to introduce the technology and also the first to extend it into the monocoque body with the Traction Avant of 1934 using Budd's latest developments. Opel followed soon after. The spread of 'Buddism' coincided with a steady increase in car demand and the spread of Fordist practices for production and labour organisation. As a result Budd's contribution is often overlooked. Only a careful unravelling of technological developments from process innovations allows Budd to emerge as a key contributor to the modern car making system. Budd technology enabled the monocoque body, allowing the phasing out of the separate chassis. Budd style production is also highly amenable to automation. Today virtually all volume cars are made this way; Buddism has become the norm for making cars. However it is also very inflexible allowing change only at high cost and loss of efficiency.

Why Change Must Happen

Figure 4. shows the key drivers for change in the automotive industry. The fundamental issue beyond these key drivers is whether the pressures for change can be met by incremental readjustment to the product, the process and the industry itself or whether radical changes are required.

Figure 4. The Key Drivers For Change In The Automotive Industry

Issue	Manifestation	Consequences
Environmental and Safety regulation	Increasing scope and severity of regulation of the car on safety, toxic emissions and CO_2 emissions	Reaching limits of incremental improvement to existing technologies
Market fragmentation	Consumers demanding greater variety of products	Undermines economies of scale; reinforces importance of build-to-order; reduced product lifecycle
Market stagnation	Lack of volume growth in key and emerging markets	Profit growth has to be generated beyond volume growth
Design limits for general purpose all-steel cars	General purpose all steel cars too heavy to meet CO_2 reduction targets, not ideally suited to the task	Could lead to dramatic change in design concepts and material use, resulting in radical shift in production technology
Capital intensity of production technology	Capacity expanded in large increments at high cost	Results in high risk, hence conservative product design
Greater reliance on suppliers	Suppliers undertake design and delivery of complete modules	Opens prospects for rapid switch in key technologies and loss of control by OEMs
Electronic integration	Greater use of ICT systems to integrate production throughout the supply chain	Quantum shift in cost reduction and speed of response

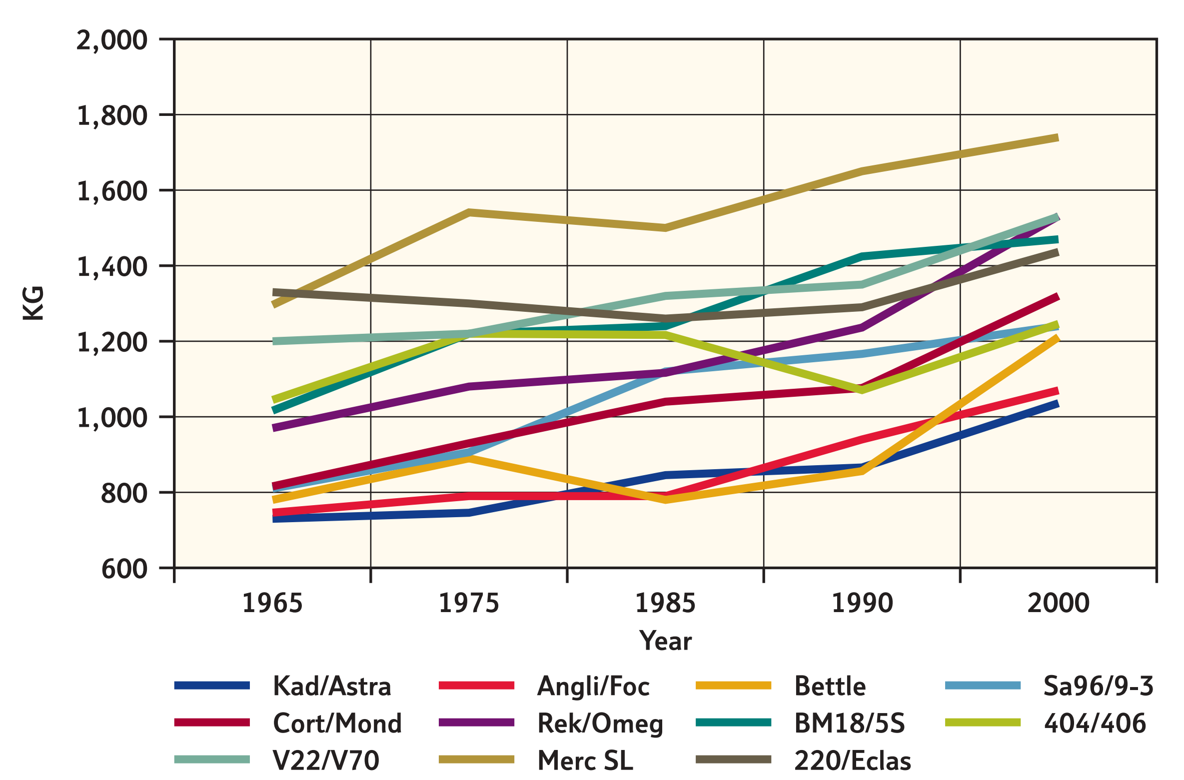
Environment and safety regulation: the impact on the car

Neither the car, nor car making as practised today, are environmentally sustainable. Automobility uses non-renewable energy and non-renewable raw materials. It also produces toxic emissions to air, soil and water, creates large amounts of waste from consumables such as oil filters, brake fluid and tyres. Cars also currently emit unsustainable levels of carbon dioxide. Finally, there is the problem of end-of life vehicles.

The car has developed into rather a baroque device which primarily carries itself and all its comfort features rather than people. Car design has been locked into a weight gain spiral. The average weight of a European car has increased from under 1,000kg 30 years ago, to around 1,400kg today. Most of the time it carries one person, just like a bicycle - which at a weight of 10-20kg achieves the same basic job - albeit at lower speed and in less comfort. The inventor of the super-energy efficient Hypercar concept, Amory Lovins, has put it thus:

"Decades of dedicated effort to improve engines and power trains have reduced to only about 80-85 percent the portion of cars' fuel energy that is lost before it gets to the wheels. About 95 percent of the resulting wheelpower hauls the car itself, so that less than one percent of the fuel energy actually ends up hauling the driver."

Figure 5. EU Car Weight 1965 - 2000



Various strands of legislation, particularly but not exclusively in the European Union, are putting further pressure on existing design concepts for the car. In fact, the coming 10 years or so will see the toughest series of standards for cars in history. These are summarised in ***Figure 6***.

Figure 6. Future EU Regulation And Agreements

Issue	Date(s)	Comments
Toxic Emissions	2005 Euro IV 2010 Euro V	Petrol and diesel standards
AutoOil	2005 Sulphur free fuel	Necessary for direct injection petrol engines
Carbon Dioxide emissions	2002 Intro 120g/km 2003 Average 165-170g/km 2008 Average 140g/km 2010/2012 Average 120g/km	Impacts on all aspects of vehicle design, especially weight, and so critical for future materials choices
ELV Directive	2006 85% recycling 2015 95% recycling	Market forcing for recycled materials
Safety	2005 Pedestrian Protection Agreement	New strand of regulation, likely to be extended

All of these will have a major impact on the way cars are designed and built. And unlike most previous legislation, these measures will not only affect engines, but the whole car. Probably the most far-reaching is the voluntary agreement on CO2 emissions, put in place as part of the EU commitment to meet the Kyoto Protocol on greenhouse gas emissions. Although powertrain and alternative fuels will have a major role to play in reducing CO2 emissions, this will impact on the whole car. Weight reduction is becoming a major issue and the tougher 120g/km limit currently agreed as an average for 2010/12 is going to be a challenge to meet. ***Figure 7.*** shows some of the few cars that currently fall below this limit; by 2012 this is to be the average figure for all new cars. Some of the other requirements may well run counter to what is needed to meet the CO2 agreement. As customers are unlikely to accept dramatic downsizing within this timespan, other radical solutions may have to be found and introduced within little more than one model generation.

Figure 7. The Lowest CO_2 Emitting Cars In The UK Market

Manufacturer	Model	CO_2 g/km
Honda	Insight 1.0	80
Citroën	C3 1.4 HDi	110
Peugeot	206 1.4 HDi	113
Toyota	Prius 1.5-hybrid	114
Renault	Clio 1.5 dCi	115
Audi	A2 1.4 Tdi	116
MMC	Smart petrol	118
VW	Lupo 1.4 TDI PD	119

(Source: Derived from Autocar, 2002)

This suite of regulations and agreements will put the EU at the forefront of vehicle environmental regulation; a position held until now by the State of California in the US. However, California retains its leadership role in some areas, such as the zero emissions vehicle (ZEV) mandate and the decision to apply identical emissions standards to all cars and light trucks, regardless of engine type or fuel type.

Neither should 'informal' regulation be ignored. There have been numerous examples of non-governmental organisations and the media raising new issues for vehicle manufacturers to deal with. Examples include the 'Elk test' that famously caused the Mercedes A Class to be re-designed, and the Swedish 'Rototest' approach to fuel economy evaluations. Many organisations around the world have created their own Environmental Rating Systems. Even the EU supports this type of informal regulation, through the non-mandatory, but highly influential, EuroNCAP vehicle crash tests.

Market liberalisation and fragmentation: the impact on car making

Mass car production is at its most efficient if an identical car can be made over and over again in large quantities. This way the same fixed investments can be used as efficiently as possible thereby reducing the unit cost of each car produced - **economies of scale**. The problem is that car buyers increasingly want different cars - visually different and, increasingly, functionally different cars. The mini-MPV segment pioneered by Renault's Scénic is an example. Making these differences complicates the production process and puts up the cost per car produced, whilst reducing volumes per model variant produced. Since the introduction of mass production this demand for differentiation has grown and as a result it has become very difficult to retain economies of scale.

Figure 8. Market Share For The Top Ten Models And Leading Model, Selected Markets, 1994 and 2000

	1994		2000	
Market	Top 10 share (%)	Leading model share (%)	Top 10 share (%)	Leading model share (%)
Netherlands	34.7	6.8	34.5	5.2
Spain	49.4	6.0	45.6	7.2
UK	47.6	7.5	35.4	5.1
Sweden	59.1	14.2	43.3	10.2
Switzerland	33.9	4.7	27.6	5.1
France	51.0	9.8	52.9	9.6
Italy	50.9	16.2	41.6	11.2
Germany	48.2	12.1	38.5	9.3

(Source: derived from SMMT Yearbook, 1995 and 2001)

In all but one of the markets shown in ***Figure 8.*** (France) the share of the top ten models has fallen between 1994 and 2000. In all but two of the markets (Spain, Switzerland) the share of the leading model has fallen. The anomalous position of France might be explained by the recent resurgence in both Renault and PSA, with class-leading models and striking styles enabling a growth in domestic market domination. Elsewhere the decline in the share accounted for by the leading models is quite marked. In the UK, for example, the share fell from 47.6% to 35.4%. However, in general terms the data in ***Figure 8.*** suggest that local market dominance has been eroded, and with this erosion has come a decline in volumes for core models. A clear example is Sweden where the leading model in 1994 (the Volvo 800) claimed 14.2% of the market, while in 2000 the Volvo S/V/C 70 claimed 10.2%.

Figure 9. Brands, Models And Variants In The UK Market, 1994 to 2002

	Brand Names	Models	Body Styles	Variants
1994	54	205	300	1303
1995	56	211	309	1580
1996	57	218	321	1624
1997	53	225	318	1611
1998	54	231	382	1637
1999	52	240	332	1759
2000	57	262	357	1931
2001	58	260	351	2042
2002	57	263	387	2472

(Source: CAIR, derived from Autocar, 1994 to 2002)

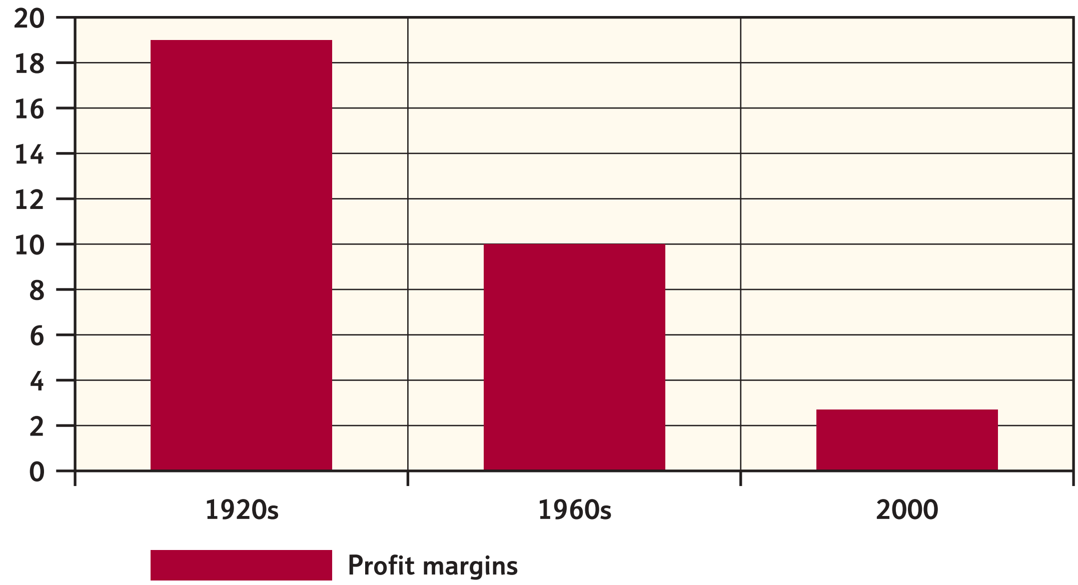
The growing popularity of diesel engines has resulted in an increase in the number of variants available within a model range. In some cases the growth in variants is indeed impressive, see ***Figure 9***. The mainstream Vauxhall Astra 5-door, for example, had 14 variants in 1996, and 20 by 2002, an increase of 43% in only 6 years. Taking all the Astra body styles into account there are 53 variants available in 2002, compared with 35 in 1996. Locally dominant models are likely to be offered with a wider range of variants than those with a marginal market share.

In the period between 1994 and 2001 the UK market grew in volume terms from 1.910 million units to 2.250 million units, while the number of variants grew from 1,303 to 2,042 (and even more startling to 2,472 in 2002). This means that in the eight-year time period the number of variants available on the UK market has grown by 89%. If registrations were equally divided among all the models this would mean an average of 1,465 sales per variant in 1994, falling to 1,101 sales per variant by 2001. One partial explanation here is the growth in the popularity of diesel engines in the UK market. As this popularity has grown, so the effect has been almost to duplicate the petrol range of variants of any one model.

Declining viability of Buddism

Modern car making is largely defined by Budd technology and making car bodies determines to a great extent the economics of modern mass car making. While assembly can be economic at virtually any volume, all-steel body manufacturing is only economic at high volumes with the theoretical optimum economies of scale arising at around 2 million a year. As long as cars are made in high volumes, each body made is relatively cheap. Conversely this technology also determines the very high breakeven points in car making and therefore forces high production levels and market-push. It is cheaper to have cars sitting in fields unsold, than to switch off the factory. Longer term trends, however suggest that mass car making has become less profitable over time. In essence, Budd technology became the foundation of early mass production and underpinned the success of companies such as GM, but is equally implicated in the declining profitability of the industry today. ***Figure 10.*** illustrates the long term trend in profitability at GM.

Figure 10. Decline Of Proit Margins In Volume Car Making: GM 1920s - 2000



Declining viability of Buddism - continued

As ***Figure 10.*** shows, the profit margins (as a proportion of turnover) of General Motors reached levels of just under 20% in the late 1920s. By the 1960s profit margins had declined to around 10% and to a more worrying 2.7% by 2000[3]. We can speak of a steady decline in profitability since the start of mass production. As far as we are aware there is no magic technology or other profit source in the pipeline at GM or any of the other mass car producers. We therefore have to assume that the decline will continue to render car making essentially unprofitable over the next few decades, unless the customer can somehow be persuaded to pay more - is this likely? For these reasons we consider that, regardless of any other consideration such as environmental demands, the automotive industry must change the core technology of its products and the processes used to create them.

Why Change May Not Happen

Figure 11. summarises some of the key forces that will hinder or prevent change in the automotive industry. It has to be remembered that this is a vast industry, hugely important to the domestic economy of many large countries, and the political risks of change may themselves be too great to contemplate.

Figure 11. Key Forces Preventing Radical Change In The Automotive Industry

Issue	Manifestation	Consequences
Globalisation	Mergers and acquisitions, alliances and FDI	Makes possible multi-brand platform strategies; raises barriers to entry
Free trade liberalisation	Reduction in extent and severity of import controls, quotas, tariffs; free movement of capital	Ultimately likely to increase global market size and international trade in new and used cars; underpins globalisation and consolidation in the sector
Platforms	Common platform used to support several models	Recaptures economies of scale lost to market fragmentation; maintains viability of all-steel vehicles
Residual profitability and partial meeting of demands for sustainability	Industry still manages to make some profit while meeting some environmental demands	Compared with high cost, high risk exit strategies it means there is still hope for reasonable returns
Existing investments	Car production and distribution investments have long useful life	Raises barriers to exit, Industry focus on variable cost of production only
Entrenched familiarity with existing car technologies and materials	Deep rooted familiarity in all areas of the industry, especially in vehicle service and repair	Difficult to introduce new materials and technologies

Figure 11. Key Forces Preventing Radical Change In The Automotive Industry - continued

Issue	Manifestation	Consequences
Entrenched infrastructures	Petrol and diesel infrastructures are embedded	Difficult to introduce infrastructures for alternative fuels, especially hydrogen or transition fuels pre-hydrogen
Enhanced efficiency	Application of electronic integration to the automotive industry	Reduces the need for fundamental change to core production and product technologies

Globalisation and free trade liberalisation

By selling the same model worldwide, rather than in just a few markets, vehicle manufacturers may return to the output volumes needed for minimum economies of scale. In broad terms there are three main mechanisms to achieve global coverage:

- **Mergers and acquisitions between vehicle manufacturers from different geographic regions in terms of manufacturing facilities and market presence;**
- **Direct investment from small-scale 'kit' assembly operations (CKD, SKD) to full-scale vehicle manufacturing;**
- **Exports from existing vehicle manufacturing operations.**

The need for complex logistics is also inherent in the current system; the large centralised factories operate at the centre of massive logistics networks. The core competence of many vehicle manufacturers and some of the larger 'tier 0.5' suppliers has become their ability to organise and integrate these logistics chains. The most visible end of the logistics activity is the movement of finished goods. Dedicated ships capable of carrying up to 6,000 cars, operated by specialist shipping firms such as Wallenius-Wilhelmsen or in-house firms such as Hyundai Merchant Marine carry several million cars around the world every year. Land-based firms, using road or rail, interface with these flows to move cars from factory to port or to distribution centres and from such centres to dealers.

Moving cars around has been described as 'shipping air' as it is a high-volume low-density cargo[4]. The high value and relative fragility of cars also leads to costly repair and losses. The most valuable cars are shipped in containers one car at a time. The shipment of new cars from the main shipping region, the Far East, to the main markets, North America and Europe, represents one of the world's largest trade flows and one of the most complex logistics supply chains involving finished or near-finished goods. In 1998, for example, global car shipments stood at 7.5 million units.

Scale economies gained from mass production at a few very large sites largely dictate the size and location of assembly plants which, in the Far East, are invariably close to the coast, utilising often dedicated ports and shipping line capacity. At the import gateways, pre-delivery inspection (PDI) facilities interrupt the flow of vehicles to distributors, and considerable buffer-stocking is in evidence. More logistics providers are moving up the logistics chain offering value added services to vehicle producers. One example is 'production line clearance' whereby logistics providers actually operate inside the plant, taking cars off the end of the assembly line and moving them into their own system.

The process of moving a car from the manufacturing facility to the customer now represents a significant proportion of the customer lead-time, and of the car's cost. In fact, around 30-40% of the price of a car may represent post factory gate costs. The new agenda of moving towards the realisation of the theoretical '3-day car', i.e. three days from customer order to delivery to that customer is beginning to focus corporate minds more on this process.

Moving cars takes time. Shipping a car from Japan to Europe will take around three weeks, after which the usual land-based logistics system can begin to take over. Whilst customers may be prepared to wait some time for a personalised Nissan Z, they are likely to want a base model Nissan Micra rather sooner - hence the need to produce certain models nearer to their target markets.

Those manufacturers, such as the Japanese and Koreans, who rely on shipping for a significant proportion of their products to reach their target markets are forced to compromise somewhere along the line. Basically, the options are:

- **Long customer lead times while cars are at sea or being processed in port;**
- **Large stock held near the target market; or**
- **Lower levels of stock made possible by offering customers more limited choice in terms of product variants and extras.**

Offering products fully specified is a partial way around this.

Platform strategies

As outlined earlier, another way of recovering volumes is through a platform strategy. The platform traditionally is that part of a modern car body that has taken the place of the chassis. The platform holds the fixed points to fit suspension, engine, transmission, etc. In terms of product development and production costs it typically represents up to 40% of the total body structure. Recently the definition of platform has broadened somewhat to include a set of key components and subassemblies that may be shared among different models. In a platform strategy a carmaker tries to minimise the number of these expensive platforms by making as many models and variants as possible from as few platforms as possible. Thus Renault's Mégane platform yielded a saloon, hatchback, coupé, convertible, MPV (Scénic) and estate. Fiat has been pursuing this approach for some time and has achieved considerable variety on some of its platforms. One example was the type4 platform of the 1980s, used for the Fiat Croma, Lancia Thema, Alfa Romeo 164 and Saab 9000. However, currently the best example is the VW

group. Here the following models all share the same basic platform: VW Golf, Bora, New Beetle, Audi A3 and TT, Skoda Octavia, SEAT Toledo and Leon. These all share the A4 platform, although the proportion of commonality varies from 80% down to 20%.

Powertrain

There is clearly further scope for platform strategies to achieve economies of scale. In other areas, notably engines, greater volumes can be achieved through joint ventures and alliances such as the link-up between Ford and PSA to produce diesel engines. In addition to the other cost pressures already outlined, the cost of engine development has also risen dramatically over recent decades. Historically, engine generations could last several decades with gradual improvements and performance enhancements. New requirements due to fuel economy demands and emissions legislation have reduced the time an engine generation can be made to last. New requirements for more diesel variants, the move to direct injection petrol and common rail diesel have further speeded up engine development. Thus costs escalate, forcing many manufacturers into engine development alliances or purchasing agreements.

This trend is still accelerating with several new IC engine technologies in the pipeline as car makers and their suppliers attempt to accommodate new phases of emissions legislation, as well as CO2 reduction. Technologies include more variable valve timing, electronic valve actuation (removing the need for a camshaft), variable compression (a Saab technology). The move to hybrid power also adds complexity and cost. At the same time, engines have to be adapted to run on alternative fuels while longer term investments in alternative powertrain such as fuel cells also impact on stretched development budgets.

Entrenched knowledge and infrastructures

The all-steel vehicle and the internal combustion engine are familiar, and hence the existing technologies have the advantage of being incumbent. This simple fact has echoes throughout the design, production and use of cars. For example, design tools are better developed for steel forming techniques compared with other materials and processes. Impact regulations are designed around the capabilities of the all-steel vehicle. Engine plants are highly automated, high capital facilities (typical investment £500 million) but limited to making IC engines.

Repair and maintenance techniques and infrastructures are readily available for vehicles using established technologies. Petrol and diesel engines are a ubiquitous technology so there is no danger that a consumer will be stranded owning a product that cannot be supported. The issue of consumer risk is often under-appreciated, particularly for a high-cost item like a car. Few customers are prepared to act as guinea pigs for novel technologies, however environmentally concerned they may be. Government regulators, tax authorities, the insurance industry and others can all feel comfortable with existing technologies.

Just as importantly, because the existing technologies are strongly entrenched, there is a major incentive to continue to improve those technologies. An interesting example is the ULSAB programme, launched in the later 1990s by the world steel industry to repel the threat of aluminium and plastic. This programme demonstrated a range of new steel types, new steel processing techniques such as hydroforming and laser-welded blanks, and new techniques for vehicle design and construction. The power of the ULSAB approach is that weight reduction and cost reduction can be offered without the vehicle manufacturers having to abandon existing investments.

Insufficient impetus for change

The car is already changing, but changing incrementally, without threat to the existing system. Engines and transmissions have become more efficient, alternative lower-carbon fuels are becoming more widely available and recyclability is improving. There are now even signs of an improvement in overall CO2 output. Engines now emit a fraction of the harmful emissions of cars of only 20 years ago. ***Figure 12.*** illustrates the average CO2 emissions per new car sold on the UK market. Looked at another way, average fuel economy for new cars in the UK has improved from 32.5 miles per gallon in 1980 to 38.5 mpg in 1999[5].

Figure 12. Average CO2 (g/km) Emissions Per New Car Sold On The UK Market

Year	Emissions
1997	189.7
1998	188.3
1999	184.9
2000	180.9

(Source: SMMT, 2001)

The agreement between the European cars makers' representative body ACEA and the European Commission to reduce average CO2 emissions of new cars is also beginning to show results. Future rounds of toxic emissions regulation, Euro IV and Euro V are expected to make the internal combustion engine as clean as is reasonably possible, with particulate traps reducing emissions of PM10s from diesel engines. The European end-of-life vehicle (ELV) directive, aimed at making car makers pay for processing old cars is being implemented. All these positive results are beginning to lull some into a sense of security about cars and environment that is, in reality, unjustified.

In the automotive industry, the technologies and techniques being created for digitally-enabled flexible manufacturing systems are being applied within the context of old-style industrialization - similar to the way Ford adapted new manufacturing methods to an old-style vehicle design. Such applications yield short-term and marginal improvements in efficiency, and hence can be seen as 'successful' compared with prevailing practice. The same thinking is applied to environmental issues. Engineers and designers may arrive at new process steps, new manufacturing techniques, more sophisticated inventory control systems that contribute an incremental improvement, a tiny sliver of competitive advantage. The gains from this type of innovation are not enduring or profound, either in a business efficiency sense or in an environmental sense.

Enhanced efficiency

There is huge scope for contemporary manufacturing to benefit from enhanced efficiency through electronic business integration throughout the supply chain - enabling the automation, integration and collaboration of resources and processes across the chain. At present the automotive industry is overlaying electronic integration on existing business practices while seeking the development of the new ways of working that electronic integration will allow.

Using supply chain management solutions, manufacturers can optimise procurement costs, improve management of suppliers and improve customer relationships.

Syntegra, a consulting and systems integration subsidiary of BT, helps to optimise the supply chain functions of manufacturing industry. By setting up collaborative supply chain management platforms - typically internet portals that run on private exchanges - common standards and relevant data can be shared by authorised parties to improve workflow. Such a system can lower costs, maximise profits and increase sales.

Automotive, high-tech and complex aerospace manufacturers in the UK, the US and the rest of Europe are also being helped by Syntegra's collaborative product development (CPD) system. This web-based environment can bring together an entire design team in real-time, regardless of geography, allowing them to use the same business processes and work from identical, current information.

A good example of enhanced efficiency potential is with Customer Relationship Management. Recent research commissioned by BT and carried out by CAIR showed that the potential for CRM to reduce transaction costs, accelerate throughput times and transform the attitudes of consumers was being stifled by long-standing antipathy and distrust between vehicle manufacturers and their franchised dealers. Lack of consistency and the relatively slow adoption of new media such as the internet have acted to suppress progress further. Still, the research also showed that, properly applied, CRM could yield both happier customers and more profitable businesses.

The latest BT CRM technology, for example, enables companies to reach and attract new customers through voice, web and mobile channels, integrating them all to make communication smoother. Traditional call centres are evolving into multi-media contact centres, customers are being given more 'self-service' access to information and non-critical activity is increasingly being outsourced, to enable a greater focus on core competencies.

Another method of enhancing efficiency is to make full use of the internet, which has changed the face of modern business, opening up new markets and speeding up communication and information sharing. A credible internet presence can help strengthen communication with employees, customers and suppliers - especially those in far-flung locations - and develop a thriving e-commerce business.

CRM capability

BT can design and implement a truly multi-channel environment to enable clients to reach, exploit and profit from customer interactions.

BT's USP is in multi-channel integration. BT has the ability to provide our clients with the channels to market to enable them to reach and attract new customers and integrate these channels to work together - across voice, web and mobile - from consultancy through to delivery of applications, systems integration, network services & hardware. BT is the only CRM partner that can provide end-to-end solutions to integrate all customer channels.

- **Multi Media Contact Centres** - New forms of customer interactions are constantly emerging.
- **Contact Central** - A proposition aimed to assist clients with the evolution of a traditional call centre into a multi-media contact centre
- **Self Service** - Creating processes whereby the customers can get information themselves.
- **Managed and Professional Services** - Includes managed networks, hardware and software
- **CRM Applications (Business Intelligence)** - Will enable customers to reduce cost of managing relationships.
- **Outsourced Contact Centre** - Organisations can focus on core competencies by outsourcing non-critical activity.

Supply Chain Management

BT Supply Chain Management offerings enable the automation, integration and collaboration of resources and processes across a supply chain.

BT offers Supply Chain Management propositions that are designed to:

- **Optimise Procurement Costs**
- **Improve Supplier Management**
- **Improve Customer Relationships.**

Online trading

Creating e-storefronts for clients wishing to trade online.

Online communities

Providing businesses with a tailored one window to all the various horizontal and vertical marketplaces available online.

Order Management

Integration of software to help call centre's manage the visibility and status of stock and orders to the point of customer acceptance.

Fulfilment

Integration of software and logistics provision to help organisation fulfil both electronically, fiscally and physically their order promise.

Smarter Buying

To help organisations improve their negotiation position and increase their administrative effectiveness of the full buying cycle for non-direct goods and services.

These can be implemented as either:

1. Solutions to optimise one particular process along the supply chain (e.g. installation of an eProcurement system to lower the purchase cost of indirect materials), or:
2. Broader solutions to optimise multiple processes along the supply chain (e.g. the implementation of a Supply Chain Planning system to improve forecasting, optimise inventory levels and minimise overall sourcing costs).

Websites

The Internet is changing the face of modern business. At the very least, it can open up new markets for companies of all sizes. However, it is far more versatile than that - it is a highly effective means of rapid communication; a gigantic information resource; and an indispensable business tool for selling and buying products and services. It can reduce costs, increase efficiency and boost productivity.

BT has a wealth of expertise in all aspects of online operations. We can help you to establish a credible Internet presence; strengthen communications with employees, customers and suppliers; and develop a thriving e-commerce business.

Websites - establishing a presence on the web

The Internet is far more than just a giant repository of information. It enables you to provide a more powerful service to your existing customers, whilst also offering a shop window for your products and solutions, through which you can attract new customers on a local, national or even global basis.

BT's Content Hosting Dedicated Servers are proactively monitored to ensure a high level of server performance. We have now extended this functionality still further with our Premium Reporting Services package. This provides you with extra services and a range of reports that can help you to optimise server performance and maximise efficiency.

Redhouse Solutions are working closely with BT to make it easy for you to establish and maintain an effective presence on the Internet. They provide websites that are cost-effective, and easy to use and maintain; but which are also high quality, best of breed sites at unbeatable prices. Redhouse Solutions offer a range of off-the-shelf websites designed to meet the needs of specific industries.

BT's fast, efficient hosting and connectivity combined with Redhouse Solutions' web design and development skills provide a powerful, complete website solution. With a consultant design team that has a wealth of experience across a range of industries, we can develop a solution that meets your particular business needs.

Premium Reporting Services enable you to access detailed traffic analyses; server performance reports; security audits; application assessments etc. One element of the portfolio is WebTrends - a comprehensive reporting solutions for high traffic sites that will help you to analyse your site's effectiveness.

BT offers a comprehensive e-Business Consultancy service that will show you the efficiencies and cost savings that are possible if you start to use web-based technologies. The four-day consultancy provides a strategic audit of your business process and practices against the business drivers.

You will be given a detailed report with recommendations on current systems and processes and your work environment, showing how and where new web technologies could be used to enhance the efficiency of your business.

Future Trajectiries

Future knowledge

The future is of course unknowable, but it is also to a large extent created by the decisions made today. There are several techniques for seeking and managing future knowledge:

- **Traditional forecasting**
- **Visioning**
- **Delphi forecasting**
- **Technology roadmaps**
- **Socio-technical forecasting.**

Each approach has certain merit, and is suited to particular conditions and forecast horizon.

Traditional forecasting is most commonly applied to predict future sales of new cars and related markets, usually in turn based upon forecast economic growth rates. This methodology is best suited to relatively short-term forecasts and rests on the basic assumption that what has happened in the past can be extrapolated into the future. However, it cannot cope with unexpected major events - and yet it is these that have the greatest impact on business.

Visioning is more controversial, usually involving the personal views of a particular expert or somebody with a passionate interest in one aspect of the future. Visioning often appears in popular media, in films, television, science fiction books and so forth. Visioning often provides a focus for change trajectories, and end point or destination ideal state. Amory Lovins' work on Hypercars fits into this category.

Delphi forecasting is probably the most frequently applied technique because it combines a large number of expert views to arrive at one or more scenarios, and is thereby conducive to creating consensus around the key issues. Alternatively, the issues may be obscured by combining contradictory expert views thus creating a bland compromise in order to reconcile major differences.

Technology roadmaps are a more recently developed technique, initially created by US government staff to aid the design of technology policy. The intention is to identify, along a time-line, the key steps in technology development needed to go from the present to some specific future point. Roadmaps can also include items such as the forthcoming implementation of legislative regulation (e.g. Euro V emissions regulations), and work best when an end-point or destination has been identified. They therefore require some kind of future vision, a known or desired trajectory, to underpin them.

Socio-technical forecasting seeks to combine technology forecasting with a wider consideration of social, cultural and political issues. The technique is most commonly applied in conditions of significant change, where incremental change in technology and markets is unlikely.

Vehicle design

Existing vehicle design revolves around the creation of a general-purpose all-steel vehicle. Legal, regulatory and insurance requirements constrain the definition of what constitutes a car. Generalised design leads to performance 'redundancy'. In the case of the environmental performance of cars, redundancy in this sense takes several forms:

- **The vehicle is only in motion for 5% of the time, for the rest it is stationary in traffic or parked outside the house, office, school, shops, etc.**
- **The average car can easily manage 160 kph while the maximum legal road speed is usually less than half this, particularly in urban areas.**
- **The average car has a useful range of 400 to 600 km when the average trip length is rarely 10% of this figure and a comprehensive fuel supply network is generally available.**
- **The average car can accelerate from rest to 100 kph in about 10 seconds, and often less, while road conditions are usually such that the opportunity to unleash such acceleration is rare.**
- **Most cars are designed to carry 5 adults and an appropriate amount of luggage. The average occupancy rate is 1.4 people per vehicle with little or no luggage.**
- **Some parts of the vehicle have a design life that is different to that for the vehicle as a whole. For example, in most cases nowadays the engine and gearbox are still functional when the car is scrapped at the end of its 'useful' life.**
- **There are various subsystems that are only used some of the time, mostly connected to internal climate control, or, indeed, safety.**

In other words, the average car is literally 'good for nothing'. It only manages to do all things tolerably well, but excels at nothing because it tries to meet multiple and often conflicting design criteria. Moreover, what might be termed aesthetic or comfort performance criteria tend to affect what might be termed dynamic or functional performance criteria. So the quest for a design that yields a smooth, quiet, cosseting driving experience often results in increased vehicle weight and therefore decreased performance in terms of acceleration, top speed or fuel economy.

In the future, the monoculture of the internal combustion engine and the all-steel general purpose vehicle is likely to give way to a much more variegated design landscape in which consumers will have to make more profound technical choices. A consequence will be that consumers will be less able to enjoy the comforting knowledge that they are cosseted by product redundancy. Beyond this, a further consequence may indeed be different and more flexible forms of ownership.

Some car makers never adopted Budd technology. They are now considered marginal players on the fringes of the industry, such as Lotus, TVR or Morgan in the UK, Isdera in Germany, Ferrari in Italy. These companies do however have manufacturing operations with breakeven points in the hundreds, rather than the hundreds of thousands more typical of Budd-type car plants. This shows that there are alternative ways of making cars and making them profitably. These firms use modularity and also different materials or processes such as polyester or carbonfibre bodies or hand-formed aluminium panels that do not require the high investments in metal-forming technology. For powertrain items they

often rely on bought in mainstream engines and transmissions, thus using the economies of scale achieved by volume producers. Others use flexible low investment, low volume manufacturing systems.

Many of these small non-Budd manufacturers also focus primarily on their home markets thus simplifying type approval as well as distribution. Some of the smaller players have no dealer networks, selling direct from the factory or workshop - customer care is rarely a problem for these companies. It is possible that some of the technologies used by these marginal players, such as composite bodies on steel chassis are pointers to the future of car making. Lovins goes even further, predicting the end of the Iron Age in car making:

"The modern steel car, which costs less per pound than a McDonald's quarter-pound hamburger, skillfully satisfies often conflicting demands: steel is ubiquitous and familiar…Yet this standard material could be quickly displaced – as has happened before. In the 1920s the wooden framing of car bodies was rapidly displaced by steel. Today, composites dominate boatbuilding and are rapidly taking over aerospace construction. Logically, cars are next."

In fact, composite cars are already on the increase. All Formula 1 racing cars are made of composites, not only their monocoque main structure, but increasingly also mechanical parts such as suspensions, gearboxes, brakes, etc. Many desirable sports cars are made of composites, such as the Lotus Elise, Ferrari Enzo. At street level, the Renault Espace had plastic panels from 1984 until 2002 after which higher volumes made steel feasible. General Motors' Saturn models used plastic outer panels as well and this became a marketing feature.

Powertrain

Partly in response to these requirements a number of technologies are under development. These can be classed under three headings: improvements to internal combustion (IC) engines; alternative fuels; alternative powertrain.

IC improvements include: variable valve timing, electronic valve control (making the camshaft obsolete), variable compression, petrol direct injection, improved engine management; de-NOx catalysts and particulate traps.

Alternative fuels can be used in existing IC engines. LPG is a by-product of oil refining, it gives a reduction in CO2 emissions and has been in use in many countries (e.g. Japan, Korea, Italy, Netherlands) for decades and has recently been introduced in other markets such as the UK and France. CNG and LNG are increasingly popular for cars and commercial vehicles, giving lower CO2 emissions than LPG. Bio-diesel is a fuel that can be used in most existing diesel engines and is made from crops, which makes it theoretically carbon-neutral (i.e. the crop absorbs as much CO2 when growing, as the car emits when burning the fuel). Ethanol is a crop-derived alcohol, long used in Brazil, while methanol can be made from a range of feedstocks, including natural gas and biomass. Hydrogen can also be extracted from a range of sources and is a good IC fuel, although storage is a problem.

Alternative powertrain is where the IC engine is replaced with something different; most likely candidates are:

- **Battery electric** - still hampered by limited range and high weight;
- **Steam** - quite energy-inefficient; and
- **Fuel cell** - almost a battery in reverse and apparently quite promising. Fuel cells have made enormous efficiency improvements in recent years. Two problems remain: reducing the very high precious metal content and storing the hydrogen needed to run the fuel cell.
- **Compressed air** - proposed by a Spanish-French consortium: 'The Air Car' - aimed at competing with battery electric vehicles at lower cost and lower weight.

Hybirds

One mixed solution that has emerged in recent years is the hybrid. There are two types of hybrid, series and parallel. In a series hybrid an IC engine is used to generate electricity, which is then used to drive the wheels via electric motors, as in a diesel-electric train. In a parallel hybrid the IC engine can either drive the car in the conventional manner or generate electricity, which is stored - e.g. in a battery - and which can also drive the car via electric motors. Recent hybrids, such as the Toyota Prius and Honda Insight tend to vary between these modes using electronic control systems. Hybrids use IC engines much more efficiently and can thus be seen as improved IC cars. A sub-development is the combined starter-alternator (sometimes called a mild hybrid), which is making a return, but is now also to be used to assist in moving the car during acceleration in order to reduce stress on the IC engine and thus reduce fuel consumption and CO2 emissions.

These engine technologies can be mated to improvements in transmissions currently being developed and introduced. These include automated manual transmissions, improved automatics (e.g. 6 speed) and belt-driven CVT. The Torotrak IVT may also come to market within the next few years. This should be set against the trend towards increasing use of automatic transmissions generally in Europe. By 2005, around 30% of new cars in the EU are expected to have automatic transmission, compared with over 90% in the US and Japan. Automatic transmissions can more easily be controlled by the engine management system than the driver, thus allowing further powertrain optimisation and efficiency. Even after all these improvements, cars may be cleaner and more efficient, but they are still far from sustainable.

The promise shown by the hydrogen (H2) fuel cell in recent years - due mainly to the efforts of Canadian firm Ballard - has led some observers and governments to talk of a future 'hydrogen economy'. Iceland is furthest advanced along this route. In a hydrogen economy all cars would be hydrogen-driven, probably by fuel cells, which are zero-emission at their point of use. BMW is alone in advocating hydrogen as an IC fuel, for which it is very well suited, as Mazda has also shown.

The problem for the H2 economy is to break through the 'chicken and egg' issue. The vehicle manufacturers are waiting for a H2 infrastructure before introducing H2 vehicles, but there is little incentive to introduce a H2 infrastructure without vehicles to constitute a market. Making a commitment to a H2 economy will then bring H2 vehicles to market. However, with existing technology, vehicles can only store enough H2 for very short journeys. The alternative is to produce H2 in the car from another fuel, such as methanol, but this would produce some emissions - usually CO2 - and would defeat the purpose of the H2 economy, as instead the need would be for a methanol infrastructure. Although H2 can be made from water, the energy needed to do this is around 40% of the energy contained in the H2. This energy needs to be found somewhere - fossil fuels? Things are never easy.

Electronic integration

The car is increasingly an electronic product. Not only are functions on the vehicle controlled via electronics, the car is also in electronic communication with the external environment.

Companies such as BT Ignite have developed remote diagnostics/troubleshooting systems which enable live, high quality video observation and data verification by remotely located technical specialists. Such a system offers huge business and operational benefits, as well as cost savings through reduced labour, travel and parts costs. The rapid response to customer problems also boosts customer satisfaction. Any potential down-side to making cars which are increasingly more reliant on electronic technology would be effectively offset if manufacturers provided access to their own team of specialists via remote diagnostics for particularly difficult problems.

Electronic integration via telematics (see below) opens up new revenue opportunities beyond car manufacturing, and thereby allows the migration towards 'mobility provision'.

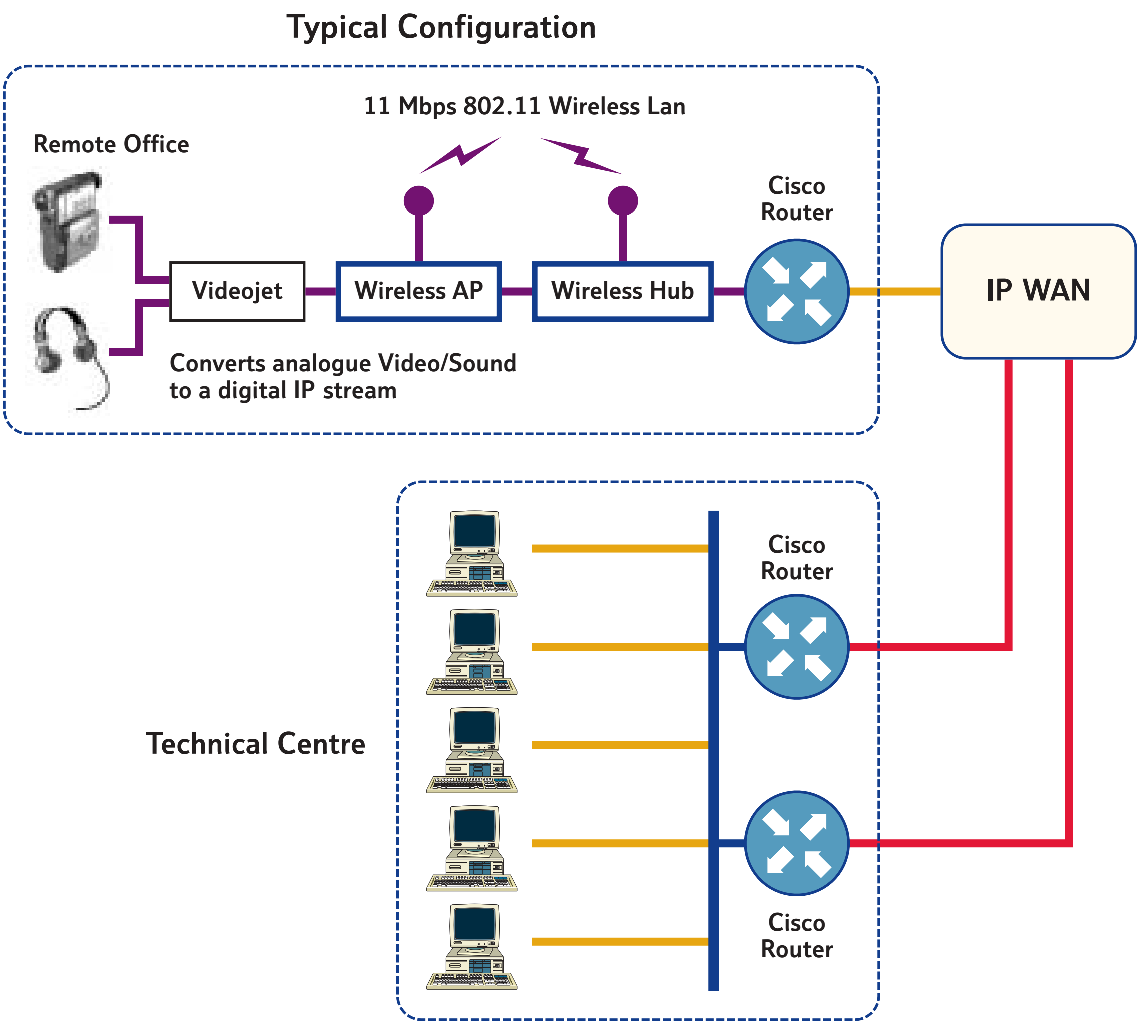
BT Ignite Solutions Managed Remote Diagnostics Service

Overview

The BT Ignite Solutions Mobile Video & Audio Transmission System (MVATS) was developed for remote diagnostics/troubleshooting in areas where wired connectivity is neither practical nor safe. Using the MVATS system, live high quality video observation and verification data can be viewed by remotely located technical specialists. The MVATS system exploits the capacity of the Internet Protocol (IP) to carry multimedia data (video, voice & data) across both wired and wireless technologies. The wide area networking can be provided either via a fixed line corporate IP network or alternatively by 2 ISDN B channels bonded to provide a 128k IP channel between Cisco routers. Calls/sessions are initiated by the Technical Centre, to manage scheduling and minimise network usage/ISDN call charges.

The BT Ignite MVATS system is battery operated and lightweight allowing the operator full movement. Battery life is dependent on usage and will typically last 1-2 hours without recharge.

Figure 13. The BT Ignite MVATS system



Managed Solution

The BT MVATS service consists of the following components:

Remote Office

- Provision, of MVATS system and Sony Cam-corder (the “Remote System”)
- Installation and acceptance testing of the Remote System
- Project Management
- Maintenance/swap-out of the Remote System
- Provision, installation and support of the network infrastructre
- Technical support
- Pro-active overnight polling and management
- Reporting.

Technical Centre

- Provision and installation support of the network infrastructure and H323 software providing a window to view, record and store the images and audio being sent from the Remote Office camera’s.
- Technical support.

The Remote Diagnostics Service is managed from a BT Ignite Solutions Customer Networks Operations Centre (CNOC). The CNOC will have access to each Remote System via the Wide Area Network. By connecting to the Remote Office, the CNOC is able to provide diagnostics up to the SNMP managed MVATS system.

Additional features

Additional features available with the MVATS system include:

- Presentation of diagnostic information to the Technical Centre (serial data)
- Presentation of Alarms and video/still pictures to a central security duty
- Attachment of a flexible (probe) camera.

The BT MVATS system offers organisations providing technical support significant business/operational benefits and cost savings through, reduce labour, travel and parts costs, whilst providing a rapid response capability to customer problems, thereby improving overall customer service/satisfaction.

Marketing

Engineers and others dazzled by the beauty of new technologies can often neglect the key point that consumers have to be persuaded to buy these technologies. For the existing vehicle manufacturers this issue is by no means straightforward, because of the relative lack of 'fit' with the brand values nurtured over the years. ***Figure 14.*** shows in broad terms the possible brand strategies available to the vehicle manufacturers.

Figure 14. Brand Management Strategies In The Automotive Industry

Strategy	Description	Example	Comments
Stretch	Extend the brand range	VW expansion into Tuareg and Phaeton	Plans for VW supercar dropped?
Acquisition	Purchase an existing brand	Many examples to create multiple brand groups	Expensive and long term strategy
Collapse	Close an existing brand	Few examples in consolidation process, recent examples include Oldsmobile and Plymouth	Usually happens when a brand loses its direction
Resuscitation	Revive a moribund brand	MG-Rover; Maybach; Spyker, Bugatti	Attempt to appeal to heritage
Innovation	Create a new brand	Lexus; Smart; Infinity; Saturn; MINI	Expensive and high risk, long term strategy

Figure 15. shows how particular vehicle manufacturers have sought to introduce environmentally friendly designs into the market. It is immediately apparent that there is no consensus on the correct approach.

Figure 15. A Comparison Of Eco-brand Strategies

Vehicle manufacturer	Model	Comments
MCC (DaimlerChrysler)	**Smart.** A 2 seat compact car with small internal combustion engines, petrol and diesel Unusual design	Positioned as a 'city car' rather than eco-brand, but very low CO2 emissions Very isolated from the DC group
Toyota	**Prius.** 4 seat small saloon with unexciting design but highly innovative drivetrain	Petrol-electric hybrid presented as an (eco) efficient Toyota, fits with overall utility/reliability image
GM	**EV1.** Electric powered with aluminium body 2 seat, sports car styling	Only car ever with a GM badge Very isolated from the group Leased not sold
Ford	**Th!nk City.** Unusual design electric vehicle, 2 seats	Positioned as an eco-brand within a multi-brand portfolio Not mainstream technology Related eco-products
Volkswagen	**Eco-versions.** Special version of models with VW badge e.g. Lupo 3L Not a radical technical departure	Small extension to the VW brand, treated in similar manner to GTI versions
Audi	**A8, A2.** Radical body design and material, otherwise conventional	Significant market differentiation not fully pursued

It is clear that creating new car technologies or shifting the centre of gravity of the vehicle manufacturers into new areas of the market are by no means simple.

Future trajectories: directions of change

Several vehicle manufacturers now talk about their role as being increasingly that of 'transport providers'. In future this could develop further. Customers would no longer buy a car outright, instead they would pay for the right to use it or another appropriate transport mode provided by the transport provider, or an associate firm, for a set monthly fee. In Germany and Switzerland, buyers of a new MCC Smart already buy into a package that includes free parking at railway stations and free or low cost rental of another Smart at their destination. Alternatively, some firms are planning a car use contract based on a cost per mile.

The car itself would become merely a means for the service provider to provide the service, rather than itself being the product to be sold. The implications of these developments - some of which have already started - are far-reaching. Personal leasing is already on the increase, with the US leading the way. In some countries, such as the UK, many people use a car which they do not own, but which is provided by their employer as part of the reward structure.

In ***Figure 16.*** we set out a number of possible future trajectories. We do not predict any of these and, in practice, elements of several may be combined. However these outline the main areas around which future shapes will crystallise.

Figure 16. Possible Futre Trajectories

Trajectory	Form	Comments
Traditional manufacturing and sale of new cars	Enhanced efficiency, greater scale and cost reduction; further consolidation; retain mainstream technology	Unlikely to meet all problems; limited scope for further consolidation; low growth rates in future
Systems integrators	Design and marketing only; manufacturing subcontracted	Industry already moving in this direction
Electronics/software	Tuning of a few hard systems to brand characteristics	Electronics or car industry? Some moves in this direction
Customer Service Trajectory	CRM systems expanded and move towards revenues derived from being an integrated mobility provider	Customer is king - true market-led business model
Mobility providers	Manage use of vehicles in the parc Cars become retained assets	Some weak moves: increased use of leasing, ownership of rental firms

Figure 16. Possible Futre Trajectories - continued

Trajectory	Form	Comments
Eco-heroism trajectory	Corporate Social Responsibility dominates as firm moves to whole lifecycle product stewardship	As with .coms, suitable business model unclear
Retail and service providers	Ownership of retail and aftermarket activities; third party branding possible	Already moves in this direction - does not sit easily with current manufacturing push
Car makers	Focus on manufacturing and assembly	Most appropriate for niche producers; too asset intensive for volume producers
Micro Factory Retailing	Combine small-scale manufacturing, sales and aftermarket in dispersed multiple small sites	Unlikely for existing industry Possible shape for new entrants redefining terms of competition
Aerospace and electronics trajectory	Cross-sector consolidation with technology areas such as aerospace; retain IC technology	Very different industries - attempts failed in the past

Future Industry Shapes

In our previous work ***The Automotive Industry - A Guide***[1] we described the existing shape of the automotive industry. However, different trajectories or development paths are now possible for the industry, and in pursuing those paths the industry will take on new and quite different shapes. It is highly possible that several possible configurations of the industry will co-exist at one time. We do not propose here that we know what the outcome will be, but seek to identify some of the possibilities and trends.

Mega-factories and satellite factories

This is a structure developed to some extent by existing players in the industry. Several manufacturers operate one very large plant building a range of different models, with a number of smaller plants making only one or two models. This way capacity in the smaller plants can be kept up with fluctuating demand for one model, while the large plant can change to more popular models. The system is used by DaimlerChrysler for example, with Sindelfingen as its large plant, or Hyundai with Ulsan. A variant is the system used to make Fiat's Palio model. Here a number of plants make major subassemblies for the car. Only by combining supplies from a number of plants can a full vehicle be assembled. However assembly can thus take place in many locations with varying levels of local vertical integration. The network operates on a truly global basis.

Modular manufacturing

Parts of the industry are well advanced along this trajectory. One example is the MCC Smart factory in Hambach, France. Here, the car spends only about 5 hours in final assembly, compared to the more usual 15-50 hours. This is possible because the final assembly process involves the putting together of a number of ready-made modules, largely sub-assembled by suppliers on the same site.

The limitation is that the car has to be designed for modular assembly, however it offers the potential for greater product diversity at lower complexity and hence lower cost. MCC also claims better environmental performance for its plant as the steel 'Tridion™' central structure is powder-coated thus saving VOC emissions, while the thermoplastic body panels are coloured in mould. In addition the supply of major modules from the same site reduces transport costs and hence energy and emissions.

Modular manufacturing is one trajectory the industry is currently moving along, although existing methods and investments limit the extent to which it can be realised in the short term.

Eco-parks

The need to put car making on a sustainable trajectory will become stronger over the next few decades. As part of this some kind of move to 'closed loop' operations will be required. Today few ELV waste materials can be recycled back to a quality easily usable for new cars. Where comprehensive recycling takes place, the waste is recycled into lower grade products for automotive or non automotive use. Indeed natural processes mirror this in that fallen leaves cannot be absorbed in that form by the plant that dropped them. Other species need to intervene before the plant can reabsorb its own waste products. Eco parks use this bio-mimicry as their basis. Here a number of businesses are combined on one site such that the waste of one becomes the raw material for another, thus closing the loop. Although at present still an ideal, experiments along these lines are taking place in Denmark. So far, no automotive firms are involved.

Mega-retailers

This model requires a shift in the centre of power in the industry from those who make cars to those who sell them. This situation already exists in many other product areas, where large retailers dominate and a large number of small producers work exclusively for one or a few retailers. At present, the necessary scale of volume car makers protects them from this scenario. If technology changes make this scale no longer necessary, the situation could change.

Micro Factory Retailing

Non-Budd technologies would not need large car factories. Non-Budd cars can be, and are, built in very small facilities, 'microfactories' with low capital investments and low overheads. Powertrain, key materials and electronic components could still be sourced from larger plants, which would accommodate the required economies of scale within the supply chain. Many components would be standardised to a large extent and small buffer stocks - of components and subassemblies rather than finished cars - would be held at the final assembly plant.

A micro factory could be accommodated within a light industrial unit. Modules for assembly would use non-paint technologies, such as coloured in-mould thermoplastics (as on the Ford Th!nk City), thus obviating the need for a paint plant with its air and water emissions problems. Aluminium extrusions or rolled steel profiles could be sourced externally for assembly into spaceframes. Powertrain units would also be outsourced from facilities that can achieve economies of scale in these technologies - much in the way most mountain bikes use Shimano gears and brakes. Interiors could be made locally from local materials by local people. Annual capacity would be around 5,000 units.

On the rare occasions you need a service or repair, or want to change the specification of your car in some way, someone from the microfactory comes to collect it in the morning. That evening (or the following morning if that is more convenient) the factory representative delivers the fixed, serviced or modified vehicle back to your drive or street, or to your place of work. This is less fanciful than it once seemed. Some dealers already offer a collection and delivery service.

Micro Factory Retailing (MFR) combines the move to a more efficient and effective way of making cars with a radical simplification of the car distribution system. It largely removes the need for dealers and for the need to ship cars around the world, benefiting both customer and environment. While creating a profitable and sustainable industry MFR is boosting local high value added jobs thus benefiting local economies, rather than remote ones. MFR would also significantly lower entry barriers to the automotive industry, making it an attractive option for new entrants.

The key here is the information and computer integration necessary to make the distributed economy a practical reality, and allow the flexibility of such a system to undermine the crude economies of scale available to existing manufacturing approaches.

The Future of Automobility

There are a number of trends in the ways cars are consumed that would make the technological changes outlined above more likely. Car ownership patterns have started to change. There is increasing pressure on the automotive paradigm as a whole as its social costs rise and its individual benefits decline: congestion, lost time, parking problems, children unable to play in the street, decline in urban quality of life, road accident and pollution victims, etc.

This may prompt a growing number of less committed motorists to abandon car ownership altogether. This is already a viable option in many urban areas in the developed world with good public transport and high personal costs of car ownership. These costs are both financial and psychological. Some of these consumers may join car-sharing schemes or create new demand for improved public transport, or opt for that other private mode - human power. Cycling has seen a revival in industrial countries such as Japan and Germany, while other developed countries - notably Denmark and the Netherlands - never gave up cycling at all. New developments in human powered vehicles make this option both more comfortable and faster, bringing more of the advantages of motorised transport to the bicycle. More recently electric bicycles have gained in popularity in a number of markets. Other motorists may keep their cars, but use them less, perhaps using car-pooling for the journey to work. They may also downsize to a smaller car.

In most developed countries the number of households is set to increase, mainly through an increase in the number of single person households. These may well favour smaller cars. The ageing population is another factor in this trend, while older people also require more ergonomically optimised vehicles. The growing number of people who rely on society for pensions and healthcare may lead to higher taxes and hence lower disposable incomes for the growing population, although a raising of the retirement age would ease this somewhat. However, car buying habits may well become more practical and less fashion-driven as a result.

This will not however, alter the trend towards an increasingly fragmented market with a proliferation of niches offering dedicated lifestyle and life-need vehicles. This will lead to a further lowering of per model volumes, putting further pressure on breakeven levels.

Telematics

Telematics brings together developments in technology within the vehicle, together with those in communications and infrastructure management. Telematics is therefore concerned with the (tele)communication of information. Telematics necessarily involves the integration of such communication and information systems, in a manner broadly similar to the convergence of computers and telecommunications that has occurred over the last twenty years. With the advent of digital communications technologies the scope for such integration has increased dramatically.

Collectively, telematic services have various terms. In North America the prevalent term is Intelligent Vehicle Highway Systems (IVHS), while in Europe the generic term is Intelligent Transport Systems (ITS). Other reference terms include 'intelligent mobility' and 'intelligent transport'. However, these umbrella terms include an array of actual or potential activities and services. Examples of these services include:

- **Route guidance, including distance to destination, travel time and alternative route selection**
- **Supplementary signage information in support of existing physical signs, for example on road speed limits, junction location and number**
- **Traffic flow rates, measures of congestion, tailbacks and waiting times**
- **Road condition information including ice, standing water and intermittent problems such as drifting fog**
- **Parking information such as car park location, cost and parking space reservation prior to arrival**
- **Supporting information for car users such as distance to services, petrol stations, hotels etc. In the longer term this type of information could be tailored by car users to their particular interests or needs, for example to identify the nearest franchised dealership for the brand of car being driven, or the nearest garden open to the public**
- **Road toll collection via electronic data interchange without vehicles having to stop**
- **Communications, most obviously mobile telephones but extending to email, text-mail**
- **Entertainment including radio but possibly extending to multi-media applications for passenger**
- **Vehicle tracking, rescue and recovery both for stolen vehicles and those involved in accidents (automatic notification of emergency services) or breakdowns**
- **Remote diagnostics, as applied to some commercial vehicles, direct communications links between on-board vehicle sensors and remote analysis facilities.**

Considerable claims have been made for telematics. ERTICO (a European organisation concerned with telematics), for example, claim that the use of in-vehicle automatic emergency call systems will increase the chances of surviving an accident by 15%. It is also claimed that telematics will reduce travel time by 25%; that road haulage costs will be reduced by 25%; and that pollution in cities will be reduced by 50%. In principle it is possible to envisage how such environmental benefits might be delivered. More efficient traffic flows will result in less stop-start conditions and hence more time spent in steady-state cruising. This will improve fuel consumption and reduce pollution. Equally, route guidance within and between cities should reduce wasted driving effort (missed turnings, searching for the destination) and hence reduce resource consumption and pollution. More likely, perhaps, is that telematics will allow more efficient and flexible road tolling, and hence allow the construction of economic disincentives to drive.

Perhaps of equal importance, in so far as telematics allows the existing road infrastructure to be used more intensively, it reduces the need for the construction of new or expanded roads. Such road building programmes have been highly controversial in environmental terms, not just in terms of the financial costs involved. It is therefore expedient in a political sense: the support by governments of telematics systems world-wide is impressive because the enthusiastic embrace of telematics enhances the image of problem-solving actions without the negative consequences of new roads. Governments are in this sense seen to be doing something, while highways agencies and departments of transport are clearly keen to enhance their own budgets and importance generally.

So, in all of these senses it would appear that telematics offers real potential environmental benefits. The added bonus for vehicle manufacturers is that such systems involve the use of physical hardware, nice items of kit that offer opportunities for 'customer delight' as well as premium pricing.

However, the rapid pace of development in the communications and personal computing industries is undermining the cost effectiveness and attractiveness of the automotive industry telematics offerings. Mobile communication, productivity and entertainment devices are significant competitive threats to OEM single vendor integrated telematics strategies, and some are now questioning the sustainability of this approach. Device proliferation, rapid technology turnover and increased sophistication of mobility services all undermine the consumer case for purchasing the OEM mass-market telematics offerings, as they appear both expensive and limited.

The current generation of mobility services will give way over the next three years to a richer tapestry of infotainment and communications services. Spread across a larger market, the cost base of these competing services will be lower than OEMs can sustain with the current integrated telematics approach. Even the current generation of smart phones and wireless PDAs are capable of supporting some telematics services. OEMs have yet to embrace the technology and create the in-car digital environment needed to release the combined potential of the automotive and communications technologies, and to maximise the value of their unique "content".

BT's advanced technology unit, BTexact Technologies, is developing an alternative strategy for OEMs that exploits three new technologies with the aim of creating the truly "personalised" car. First, using new open wireless standards such as Bluetooth and WLAN to simplify & future-proof the physical connection to the car. Second, adding in personalisation services that enable customers to seamlessly extend their e-world into the car environment. And finally, leveraging intelligent agent technologies to create a new range of services from the combination of car "content" and communications facilities.

Conclusions

Over time, the role of the car has changed. It started life as a plaything for the rich. Then it became democratised, offering access to motorised mobility for an increasing number of people in the industrialised countries. In this it developed a role as a serious mode of transport, gradually dominating this segment at the expense of other modes, such that to many transport now = cars. Its spread is still continuing into newly industrialising countries, though much of the world's population remains without. The car is now seen by many as essential, but beyond this has retained its role as toy (e.g. in motor sport 'track days'), developed new roles as fashion statement, virility symbol or office.

Increasingly such different roles will see different product offerings, both in terms of the vehicle itself and the environment where it is used. Dedicated motor racing tracks are long established, off-road tracks for 4x4 SUV enthusiasts are a more recent phenomenon. Telematics and the move to self-driving cars cater for those who want to avoid the driving function altogether and perhaps aspire to inhabiting a mobile office. All these trends in cars, car use and car production and distribution point to a radically different motoring culture in years to come. However, the most radical influence on future mobility is likely to come from the need to make our activities sustainable.

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