MUX potentially allows electronic options to be "added" during production, at the dealership or at any stage during the vehicle lifecycle.

X-by-wire technology for braking and steering can potentially reduce internal complexity through electronic control. Its benefit to 3DC is that less mechanical parts are required, such as hydraulic cylinders, brake lines and fluid. However, the first systems will retain a hydraulic back up. Complete electro-mechanical systems are not expected for between 8 to 10 years.

The 'plug and play' concept of remote electrical options is now technically feasible with MUX and CAN. However, this poses a number of issues over costs of warranty and installation. The ability to retain the current price differentials between 'plug and play' options must be questioned. This could seriously affect profit potential and any implementation must be approached extremely carefully.

Design For Recyclability

DFR can reduce part counts and drive simpler designs, for example by commonising materials used for bumpers or cockpits.

Composites and in-mould coverings, which make vehicle assembly easier, should be made with compatible materials for recycling purposes.

Recycled material is now equal to virgin material in quality and cost, but the market tends to be more volatile in terms of price and supply, tending to lead to stocks being held to cover variability of supply. Quantities of recycled material used in cars are currently low, but greater volume will reduce such supply volatility. However, the risk to lean material supply will still exist.

Cost

In addition to variable production costs, the following factors must be considered when determining the profitability of adopting new technology.

1. The saving in costs associated with vehicle stock in the market place by enabling true BTO with minimum delay and maximum mix flexibility.
2. The cost of investment for future product change.
3. The investment in plant and its effect on fixed costs.

The potential benefits of individual vehicle design technologies such as modular frame technology and plastic panels must be assessed over all these cost factors. While they may well increase variable unit costs, they can also significantly assist BTO, reduce the cost of product change, and increase the effective life span of certain types of production machinery.

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Executive Briefing

The Impact of Vehicle Design on Rapid Build-to-Order

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This research examines the technological opportunities for rapid Build-to-Order in current and future vehicle design over the next decade. The major objectives in this respect involve:

- Delaying complexity as late as possible in the production process
- Minimising production complexity while maximising customer choice
- Maximising standardisation across models to enable multi-product assembly lines

This will enable maximum flexibility of build in line with specific customer demand from the market place.
Investigation into specific aspects of vehicle design and requirements of recycling lead to the major conclusions in this briefing.

BODY CONSTRUCTION

The platform concept is based on standardised components built on a common floorpan, offering the potential for a combination of high model variety with comparatively low levels of complexity. Platforms can benefit 3DC because they can share components across models and brands (e.g. Ford, Jaguar and Volvo), increasing flexibility and potentially product mix and capacity utilisation.

Alternative methods of body construction to the traditional monocoque increase the total number of structural body parts per vehicle. This is contrary to 3DC's requirements for minimum complexity. However, if these parts can be shared across model variants and platforms and be more easily adaptable to product change, overall complexity and cost can be reduced.

The 'Independent Body and Panels' (IBP) approach de-couples paint from vehicle production. Exterior panels can be painted separately from the vehicle body, as in the case of the GM Saturn EV-1. The DC Smart car, Hambach, uses thermoplastic panels with in-moulded colour. This means that the paint shop and surface quality/reliability issues are effectively disconnected from initial sequencing on to the assembly line.

Other examples of body construction technology that can potentially enhance 3DC feasibility incude vacuum pressure aluminium die-casting, glazed roof panels / painted roof modules and hydro-forming.

Alternative methods of body construction can redefine the current limits of platform sharing. Common platform elements that have no impact on the vehicle's outer skin can be retained, whilst an almost infinite variety of new model shapes are possible from a basic kit of modular, structural components.

POWERTRAIN

A greater proportion of internal combustion engines will be direct injection diesel engines by 2010. However, competencies related to traditional powertrain development will remain with manufacturers, albeit given greater collaboration with suppliers.

Hybrid vehicles are the most likely short to medium term solution to 21st century personal transportation. However, the dual powertrain design represents a challenge to 3DC, since it is obviously more complex.

In the longer term, 10 to 20 years, there will be growth in powertrain variants, to include Fuel Cell and Electric technologies. Whilst focusing on one source of power, this will require different body, transmission, gearing and suspension design. These developments are unlikely to have a significant impact over the next 10 years.

MODULES

Modules benefit 3DC by reducing vehicle complexity in design at the manufacturer and by removing complex assembly procedures from production. Minimising internal vehicle complexity enables a BTO strategy by reducing inventories and assembly leadtime. However, this means that much of the responsibility for assembly and stocking is passed back up the supply chain.

The benefit of modularisation is derived from the concept of combining component assemblies, both internally within the vehicle and externally across individual models and brands. However, a disadvantage of sharing and standardisation is the danger of losing the distinctive 'look and feel' of individual models. This can affect brand image and the ability to price differentiate.

The current emphasis in vehicle design is on module integration, which suggests that they may become more model specific. This conflicts with the generally accepted notion that industry should increase parts sharing and standardisation across models.

Current plans to introduce painted door modules, interior modules and roof modules will significantly reduce production leadtime. The roof module is particularly relevant to 3DC as it eliminates the sunroof option during the early stages of production in BIW, and postpones it until final assembly.

ELECTRONICS

The increase in development of telematics and mechatronics suggests that cars will become more complex. It is expected that 90% of the basic functionality of future innovations in cars will be determined by electronics. However, by integrating software and assembling electronic components before the '3 day clock' commences, the problems of complexity can be overcome.

Multiplex (MUX) represents a key enabler to 3DC where a single optical fibre with Controller Area Network technology (CAN) eliminates hundreds of variations of traditional wiring harnesses.