Innovative Vehicle Architecture for Future Demands

Alongside the discussion on the sustainability of energy resources and their efficient use in future mobility scenarios as well as their impact on continuing climate change, the diversification of customer-specific profiles for future vehicle concepts determines the research and development targets of major automakers like Volkswagen. Apart from the social trends of our customer clusters, regional market-specific characteristics play a growing role in defining these profiles. This holds particularly true for the large growth markets of Asia, South America and Russia where regional mobility demands call for specific vehicle concepts. A continuous urbanization again asks for further vehicle concepts based on emissions free drive trains.

1 Introduction

For a global automobile manufacturer the demands of sustainability, efficiency and diversification increase the complexity of vehicle models and their characteristics together with associated development expenditures. The Volkswagen Group solves this challenge with "modular design systems" which facilitate the multiple uses of systems and components in very different model layouts on the basis of variable vehicle architectures. This procedure ensures the necessary design flexibility while at the same time facilitating cost- and capacity-efficient development synergies and leveraging the cost potentials derived from economies of scale with regard to both the vehicles and their production.

As Figure 1 shows, the future of mobility will be determined by several societal megatrends:

- The global population – and therefore global mobility needs – are growing fast
- Most of this growth centers on emerging markets
- More and more people are living in cities, and
- Traffic volumes, Figure 2, continue to grow, particularly in cities themselves
- The high concentration of urban traffic calls for emission-friendly drive concepts
- As fossil energy resources become scarce, there is a move to diversify alternative sources of energy which means that several alternative drive technologies will coexist.

In the final result, these trends will lead to the further dissection of vehicle segments and drive technologies. This in turn will trigger another rise in expenditure and manpower requirements for product development, not only at the big OEMs but also at their suppliers.

We respond to these challenges with a global growth-oriented strategy. An important element of this strategy is global component systems. The modular structure of such systems makes it possible to meet the specific requirements of regional markets while preserving the basic vehicle architecture. This applies both for vehicle size and for different drive technologies.

2 Global Market Development Trends

Today, the world has a population of 6.7 billion. Just over half of these people live in cities and this share is still growing. At the moment, there are around 500 cities with a population of more than one million, this number will rise in future. Of these 500, 22 are what are

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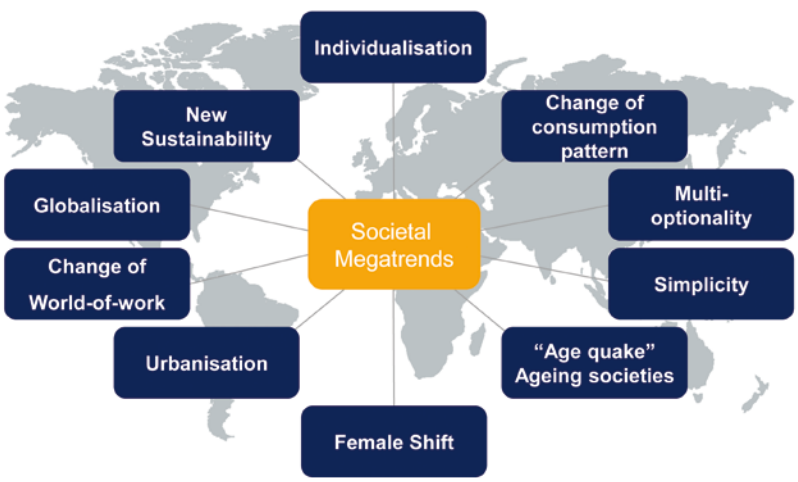

Figure 1: Societal megatrends

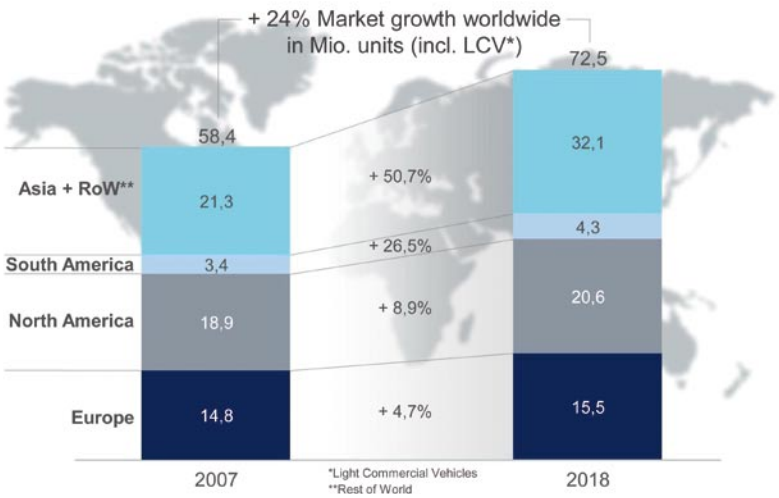

Figure 2: World car market growing

known as megacities, cities with more than 10 million inhabitants. The largest of these megacities is the Tokyo-Yokohama conurbation with 37 million people. Most of the megacities, however, are located in newly-industrialized or threshold countries.

These new megacities are growing so fast that urban transport systems such as buses and trains cannot keep pace – so people are having to rely more and more on individual mobility. By 2030, the number of vehicles in the world will have doubled. The vehicle population today is already around 800 million. At Volkswagen, we obviously see the greatest market potential in countries such as Brazil, India or China and orient our growth strategy to the needs of these markets. While we have been producing locally for the regional markets in South America and China for quite some time and have become a main player in these markets, we are just starting out in India and Russia. We are building new plants locally and are setting up dealership networks to meet the demand for vehicles in these countries.

All these emerging markets have their own specific requirements as regards vehicle design characteristics. These differ from customer wishes in traditional markets. One very important factor is that the customers' purchasing power in these regions is on a lower level than in high-technology markets. As a result, there are significant differences in the specific interaction between vehicle size and vehicle price, **Figure 3**. This means we must segment our product offering even further. We are now developing vehicles specifically designed for local markets and we use local development centers which are part of a development alliance in each respective market. This year, for example, we have presented and launched two models (Lavida and Bora) developed and built in China, **Figure 4**. In Brazil we have just presented the latest generation of the Gol, also developed and produced locally, **Figure 5**.

But even on the traditional high-volume US market, there are now big differences between the wants of our customers there and the wishes of customers on our home market in Europe. While a European profile is accepted – or indeed even explicitly desired – in premium segment vehicles, we can only be successful in the volume segments if we can reproduce the mainstream tastes of customers and their wants as accurately as possible. That means products specifically tailored to the NAR market (North American Region) and – given the currency situation – it also means benefiting from the cost advantages of local production. This is why we decided to build a new factory in Tennessee which will start production in 2010, **Figure 6**.

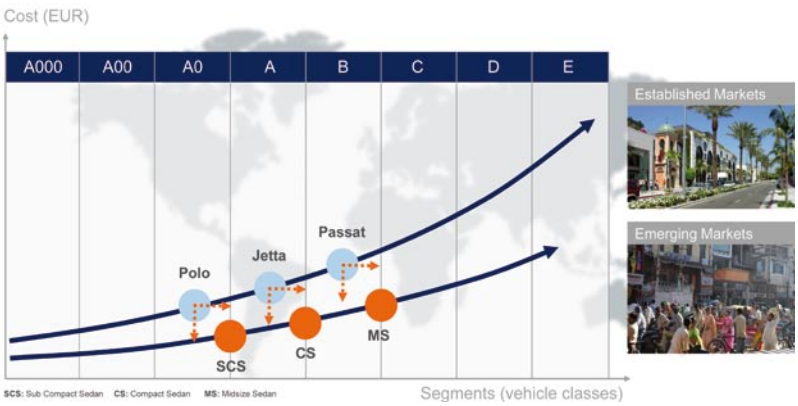

Figure 3: Different markets ask for adequate priced products

3 Sustainable Development Trends

There is another thematic complex that interacts with this market-oriented diversification. This complex relates to issues such as:

- Climate change
- Energy resources
- Continuing urbanization
- The socially-motivated spread of customer orientation towards niche segments.

The CO_2 taxation expected in Europe will give a new dimension to the issue of fuel consumption. Since customers are hardly likely to make concessions as regards vehicle size, safety equipment or comfort, vehicle weight and drive efficiency will become even more important than is already the case today. However, customers in emerging markets will not be in a position to bear the additional cost associated with this. So we will see a diversification of drive options and vehicle architecture. The lightweight materials necessary in Europe will have to be replaced by local materials in emerging markets, not least because of availability constraints.

The availability of energy resources varies in different regions of the world. While diesel and gasoline will continue to dominate the market in Europe for the foreseeable future, drive concepts in the big emerging markets in particular are likely to be determined by the fuels that are regionally available. Today, our engines in Brazil are already designed to operate as Flexfuel engines, which means they can either run on ethanol or conventional gasoline. In countries rich in natural gas resources, our strategy is oriented to CNG or LPG. In countries with a strong agriculture sector, second generation biofuels which do not compete with the food chain will certainly be very important. So it looks as if internal combustion engines powered by various types of fuel will continue to determine drive technology for quite some time.

The motivation for electric drives comes from local emission requirements in urban conurbations. Even if electric power is not the answer to all emission problems, electric drives will probably be able to reduce emission levels in critical regions. That is why the significance of electric vehicles – and of hybrids for intercity transport – is growing. The key technology here is not so much the drive as the mobile storage technology in the form of batteries. This technology still presents us with a big technological challenge today, not only as regards controlled power output but also in terms of thermal stress management and service life as well as protection against short circuiting.

Figure 4: Local products (China) – Lavida and new Bora

Figure 5: Local products (Brazil) – Gol

Figure 6: Volkswagen plant in the North American region (Tennessee)

4 Effects on Vehicle Architecture

Going forward, all our vehicle concepts must be able to accommodate these different technologies. Viable vehicle architecture must be designed to cater for both conventional internal combustion engines and a gas or electric drive package. This problem is solved for all brands by using a selection of modular design systems, **Figure 7**, which selects components from a modular toolbox. These systems are very variable, so they allow for a competitive product portfolio. This modular toolbox comprises all drive, body structure, chassis and electric/electronic components. A special module management system, **Figure 8**, uses roadmaps to ensure that the toolbox always contains competitive components.

Vehicle architecture is based on the drive configuration. There is a transversal configuration for A00 to B segment vehicles and a longitudinal configuration for B to E segment vehicles. We call these configurations the "modular transverse matrix" – or MQB for short – and the "modular longitudinal matrix" – or MLB. Both matrices have the following basic characteristics:

- Geometric variability of length and track width, height and seat position
- Standardized drives and their configuration in the front end
- Standardized axle technology and its configuration in the front and rear ends
- Different wheel sizes
- Standardized tank technology and configuration
- Standardized exhaust technology and configuration
- Standardized body structure sequence
- Standardized assembly sequence
- Modular heating and air conditioning components
- Modular seating units.

Drives, cooling system package, front axle and air conditioning have a fixed location for all engine and gearbox combinations and for all vehicle derivatives. The front end package is designed to accommodate both conventional front-wheel and all-wheel drives as well as hybrid and electric drives.

5 Modular Transverse Matrix

The modular transverse matrix, **Figure 9**, includes front-wheel and all-wheel drives based on all present and future drive combinations mounted transversally. In addition, front-wheel drive gasoline engines are combined with CNG or LPG packages. The gas tanks can be fitted under the rear seat. As far as hybrid drives are concerned, there is a choice between a parallel hybrid configuration with an electric motor fitted between the engine and the gearbox or the TwinDrive concept which features a powerful electric

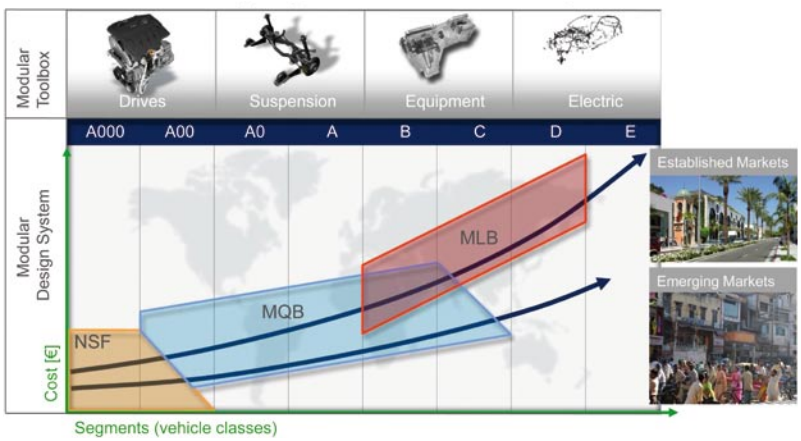

Figure 7: Modular design system – MLB & MQB

Figure 8: Modular design system – module management

motor sandwiching the clutch and transmission. This concept enables fully electric-powered, ZEV driving in the city. There is also a configuration for an all-electric drive which could be installed once the appropriate battery technology has been developed.

6 Modular Design System Synergies

The method I have described has many synergies. Almost all of these synergies relate to expenditure reduced during the product creation process. Deriving several different vehicles from such a modular design system leads to reduced development costs. These costs are lowered further with each new derivative, since the design methods interact, **Figure 10**. The factory layout is standardized because the body structure sequence and the assembly sequence are also standardized. This offers multi-flexible factories at different production locations, bringing the potential to enhance flexibility at factories and products.

The multiple use of components generates expanded purchasing volumes with investment benefits for suppliers and good prospects for efficient component production. Given the high unit volumes, suppliers can look forward to attractive depreciation of one-off expenditure.

Thanks to the modular design system, **Figure 11**, it is possible to commission worldwide development satellites to design specific regional vehicle mod-

Figure 9: Basic concept of modular transverse matrix MQB

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Figure 10: Reduction of versions but rise of volume

ules and to simultaneously network global capacities.

And finally, thanks to the modular design system worldwide development sites are able to share capacity for simultaneous development projects and to develop locally specific vehicle modules.

7 Summary

Regional requirements in growth markets with regard to automobile design will lead to the further dissection of vehicle segments going forward. In addition we expect to see the more pronounced coexistence of alternative drive technologies given the regional availability of energy resources and the increase in emission-friendly electric drives as urbanization increases. At Volkswagen, the modular design system solves the conflict between a customer-oriented product strategy and the use of resources geared to expenditure efficiency. Individual vehicles are matched with structure architectures and component design systems. The vehicles are built in regional plants with high localization rates to avoid exchange rate sensitivity. The regional plants are standardized to comply with the module sequences and are extremely flexible. Sustainable synergies are generated along the entire product creation value chain. ■

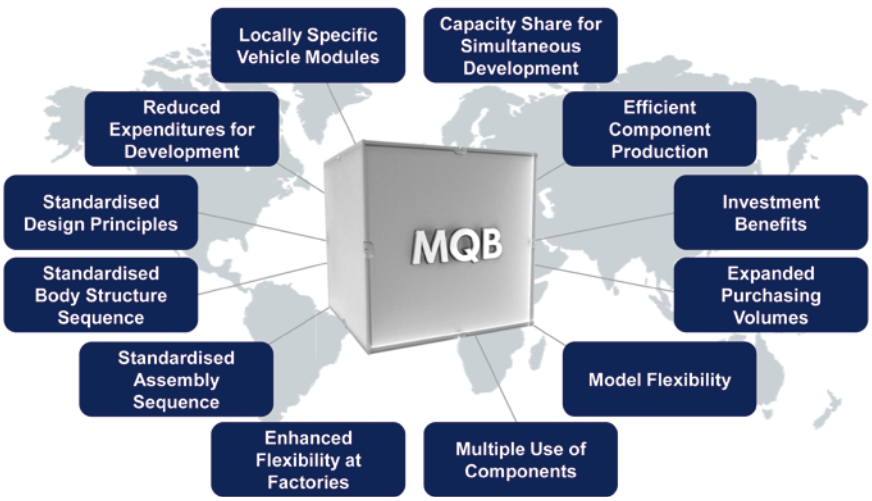

Figure 11: Synergies of modular design system

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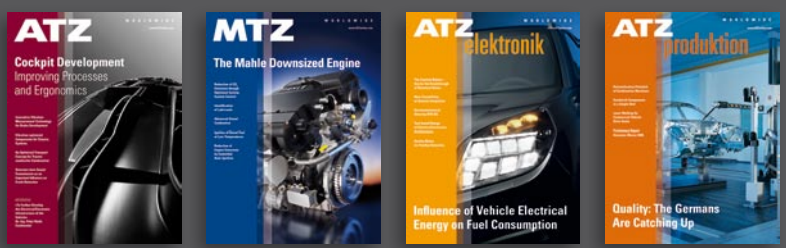

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