THE CAR IN THE YEAR 2014

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INTRODUCTION

he car, the most wanted and favourite object of a modern family is almost 128 years in the production. Officially, the first four-wheeler with the engine running on fossil fuel was a Mercedes-Benz from 1886. However, even before that, there were attempts and prototypes, which are worthy of attention because of their completeness. For instance, Siegfried Marcus from Vienna made his first car with two-stroke gasoline engine and wooden car body in 1864.

After the appearance of the first car, the development of the car has gained importance and the development of new models has begun in several countries in Europe and America. Thus, there were several car manufacturers already at the beginning of the 20th century. The development had so advanced, that, already in 1903, a car has appeared for which the aluminium superstructure was alternatively offered in sale, since, at that time, there could not have been any talk about car body. This revolutionary step was a consequence of the development of a „miracle“ material that does not rust and does not absorb water, which, back then, was of great importance, because the superstructures were made from poor iron and wood. It was aluminium, the production of which has also started in 1886. The beginning was marked by production of aluminium castings, while the first metal sheets were found in mass production in 1897. Of course, in the same year, the first sheets were already used in practice, only not for car production, but for the covering the roof of the church of St. San Gioacchino in Rome, which still exists today.

MILESTONES

Which cars have marked these 128 years of the production of passenger cars by their particularly successful concept and long-term production? One of them is certainly Daimler-Benz, the first patented passenger car from July, 1886. It was documented as a symbol of the beginning of a new era, the era of a new technical wonders. Almost two decades have passed since the appearance of the first car, when a famous Ford model had set the first records in production and technical solutions. It was the Ford Model T "Tin Lizzy" from 1908, which had been produced until 1927 and was made in more than 16.5 million specimens. It is particularly important for this model that it was the first car assembled on the assembly line in 1913 and thus it had achieved a daily production of several thousand units, which was magnificent at that time. The next car which especially marked the post-war era of personal motorization is known to all as VW "Beetle", which was based on a simple vehicle concept and was considered as a very reliable family car. Until 2003, it had been produced in more than 21.5 million specimens. In the meantime, its successor with more modern concept and design has been searched for. Thus, in 1974, the first generation VW Golf was produced and it is still produced in its seventh generation. More than 29.3 million specimens were produced in total with the sixth generation. Since we are in Kragujevac, “Zastava 600” must be mentioned, a famous and simple, small "Fica", which is a symbol of an era of development and motorization of the post-war generations in our area.

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This small car have been produced from 1955 to 1985 and 923,487 specimens has been made (Figure 1).

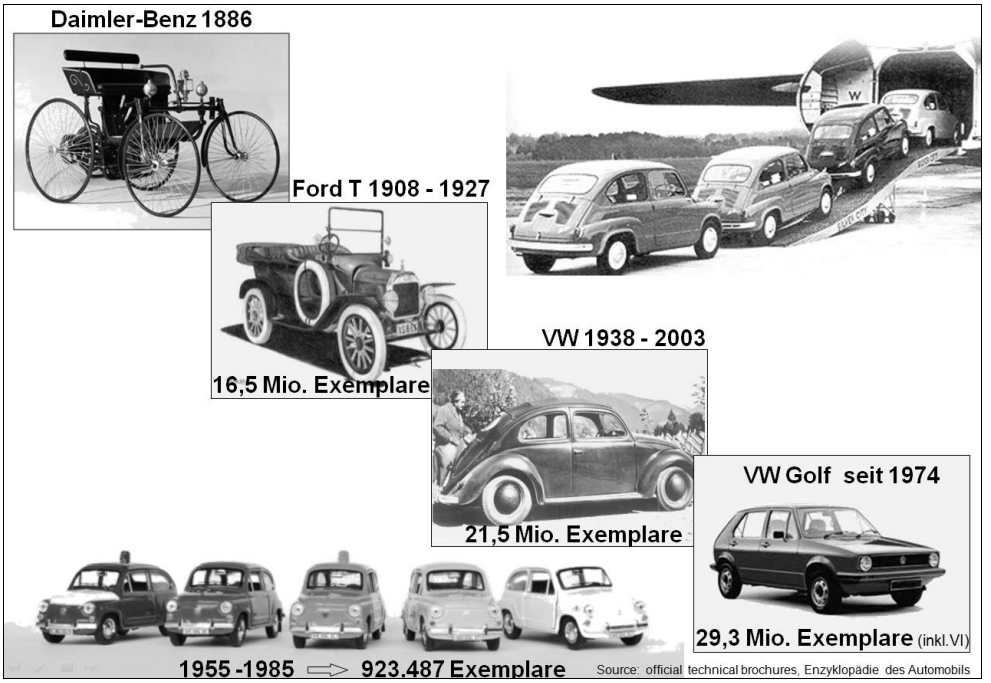

Figure 1 Milestones of motor cars

THE FIRST VEHICLE CONCEPTS

Production of the first cars has been based on a chassis - body concept, which generally represents a drive frame with the engine and the running gear and superstructure (car body) only lightly attached to the frame. Of course, this concept represented a rational, reliable and profitable production solution at the time, and it held for a long time, practically until after the World War II. Developments in technology and higher requirements, particularly in passive safety, have gradually pushed the original concept out of production. The first attempt at making a better, compact and integral carrying structure, which combines the chassis and the car body, now known as self-supporting body, was made with the model of Lancia Lambda in 1922. Of course, it was left just for the history, because the first official self-supporting body was patented by Joseph Ledwinke in 1931. The first officially produced serial car with a self-supported body was Citroen 7A from 1934. Right after that, there was Opel Kapitän, and then a large series of Opel Olympia (Figure 2). This marked the era of production of modern passenger cars with self-supporting/monocoque body, which takes and spreads the collision energy more efficiently, thus partially absorbing it and transferring it with small accelerations to the passenger compartment.

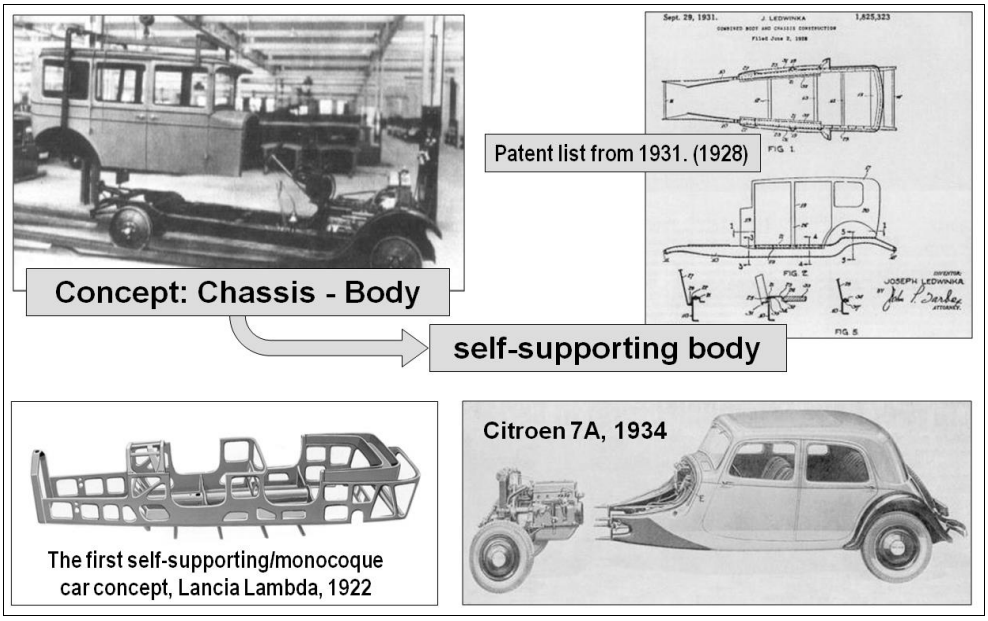

Figure 2 Car concept developments [3,4]

It is interesting to note that, already in 1953, the first car with a self-supporting body had appeared which was not made out of steel sheets, but aluminium sheets. It was the Panhard Dyna Z1, which was made conventionally, using the spot welding, without any chemical preparation of sheets before welding and without any subsequent corrosion protection. Regardless of that, an analysis from several years ago, made on one of those preserved cars that happened to be driven for a long time, have proved aluminium to be an excellent material for the car body, which opened further investments for the wider use of this material in serial production of car bodies. That car was in production until 1956 and was made in 39,460 specimens.

NEW CONCEPTS

Premises under which new concepts for passenger cars have been developed were, in general, strictly in accordance with the standards and definitions of lightweight design in the developmental stage. Figure 4 shows an Audi study of future, which is in accordance with one of the several published definitions of lightweight design.

Of course, creativity of our ancestors could not remain without visible results, so, with the help of new technologies, first in aluminium applications, a new way of designing the car body was developed, called SpaceFrame, which enabled the design of lighter, more compact, and more "crashworthy" carrying structures. These are the supporting structures, which consist of closed profiles (mainly made of aluminium), with special cross sections that are interconnected at nods through corresponding, spatially defined closed elements (mainly aluminium castings).

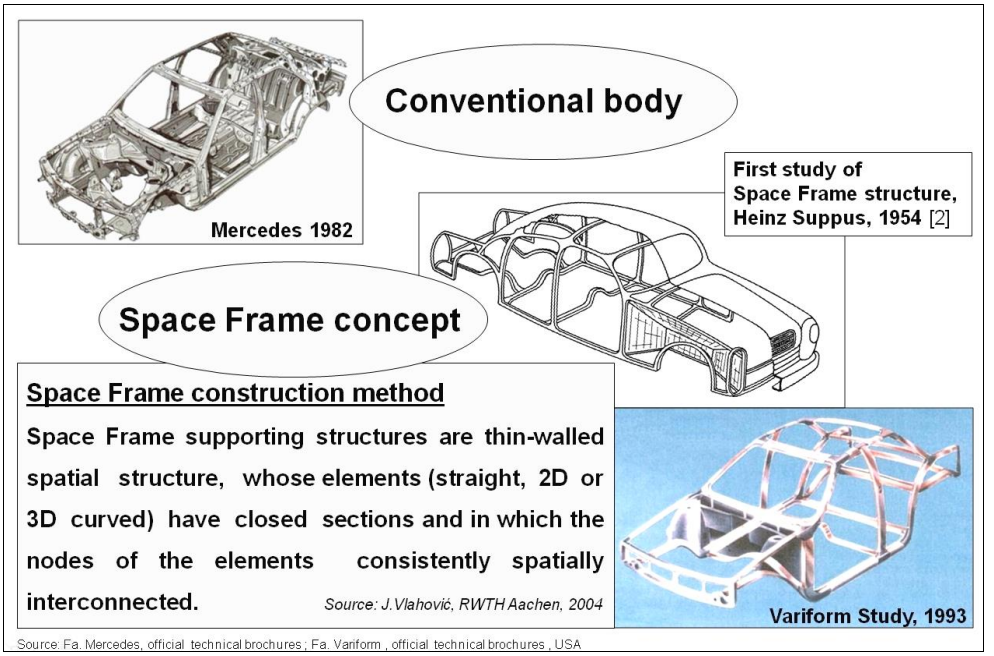

Figure 3 Lightweight design definitions

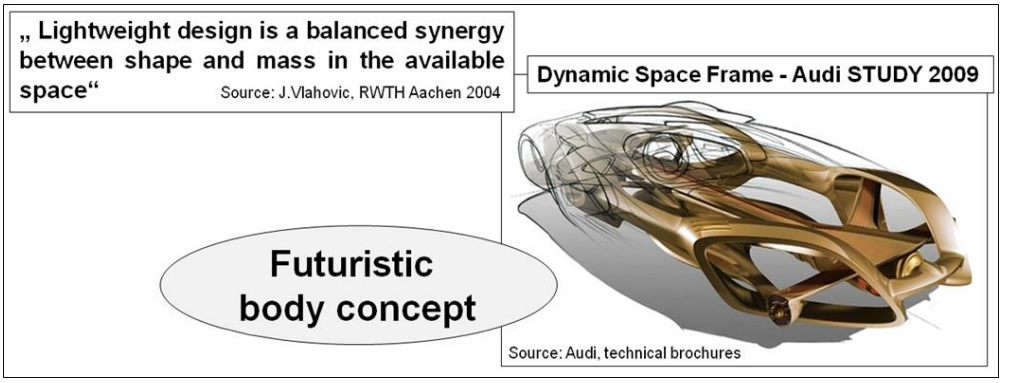

Figure 4 Different construction methods of supporting structures

The first steps in this direction can be seen already in 1954 (Figure 3) in the study of Heinz Suppusa [2], and the first car was made in several specimens by Treser (D) in 1987. It was more than surprising step in the car design - a car body which is not composed of sheet metal, but consists of a specially profiled aluminium profiles and moulded aluminium nodes. In these cars, we can no longer be talking about the car body, but of the supporting structure that takes on all static and dynamic loads and of panelling which closes it all, makes partitions and provides the optical appearance of the car body. Today, there are automobiles that have the aluminium car bodies that are made using these principles, and, officially, the first car made using this technology is the Audi A8 from 1994, Figure 5.

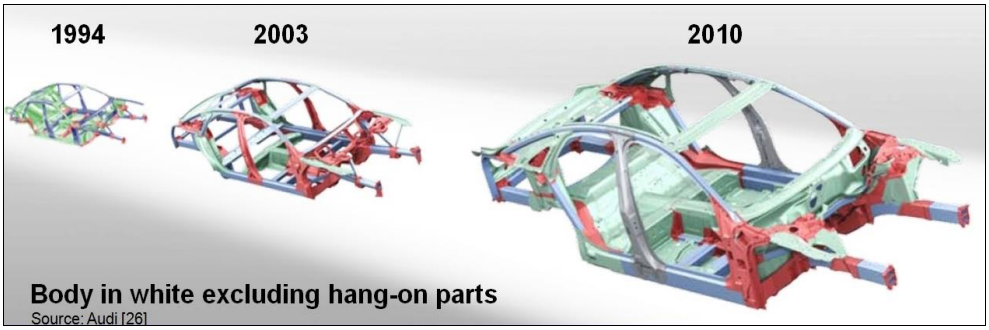

Figure 5 AUDI A8 development history

It is important to note, that, since 2008, there have been about thirty different types of cars with aluminium car body in production. As such construction (SpaceFrame) of car body of steel is concerned, it can be said that there were a few attempts to apply this type of construction of steel. Studies and prototypes were done (ARMCO study, USA, 1995, a prototype ULSAB Ultra-Light Steel Auto Body from 1996, and the prototype ULSAB AVC from 2002). Currently, this principle of construction in steel is applied only partially in serial production for certain parts of the self-supporting car bodies. Namely, the fact should be considered that certain principles of car body building, for example SpaceFrame, are more suitable for materials such as aluminium alloys. Copying of what is done with aluminium to steel will certainly not give fully effective results. For steel car body structures, there are another concepts and methods of construction today, which are elaborated in detail by Dr. Adam (ThyssenKrupp Drauz, 2009) and others.

THE LATEST DEVELOPMENT

What do we have today in large series production? Of course, mostly, highly profitable products, which implement the most optimal forms of modern techniques, but not superior technology and superior concepts of design. It may be found only in small series and exclusive cars. Today, a large series passenger car is modern in form, has reliable concept of building and is equipped with systems of active and passive safety to the maximum. Even in the basic version, modern passenger car has power brakes and power steering system, ABS (Antilock Braking System), ESC (Electronic Stability Control), multiple air bags and other previously unknown and expensive systems. Those include today both safe and lightweight car bodies, as well as economical and "clean" engines. If a modern engine is compared with an engine of thirty years ago, it can be stated that an engine manufactured at that time has produced the exhaust emission which corresponds to the value of the exhaust emission produced by at least a hundred engines today (Prof. Dr. Gruden).

ENVIRONMENTAL ASPECTS – THE CURRENT STATE

Why is it important that new cars are lightweight, with low fuel consumption and that the total exhaust emissions meet the latest relevant EU regulations? Since 1886 until today, about 2.5 billion passenger cars have been produced. About 28% of them are still drivable and in traffic. Every year, there comes a couple of millions of new cars (67.8 million in 2013), so we are approaching a mass of one billion passenger cars. If the total number of all cars in the world is considered, then we have to add about 307 million of trucks (in 2010) and about 360 million motorcycles (in 2013) to this number. It is clear that

these technical pets represent a huge thermal and chemical load on nature and they affect the remaining energy resources on earth. Figure 6 shows the annual production and the total number of the passenger cars in the world.

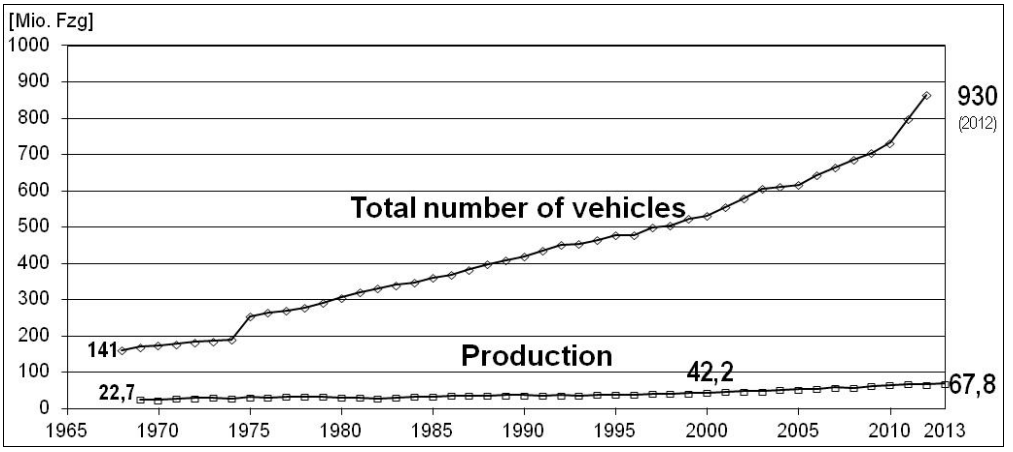

Figure 6 Passenger cars – Production and total number [1]

NEW TECHNOLOGIES IN PRODUCTION

Every day we witness the introduction of new technologies into mass-production. It's not easy, because new technologies are initially very expensive and not sufficiently mature for mass-production and dozens of years pass, from first experiments and test series, before a new technology or an invention is finally introduced into mass production. This is supported by two examples. The first one is from engine technology: two camshafts in the cylinder head and four valves per cylinder are known for decades, but just now they are an essential concept in the mass volume production. Another example is from the field of car body building: SpaceFrame construction concept is already known for a quarter of a century, but, due to the cost and complexity of tri-dimensional cross sections and welds, it would not be a dominating building technology for much longer.

Let's look at the list of currently present technologies and methods applicable in automotive production.

Method of construction (structure - bodywork)

As it may be seen from historical review, since 1886 until today, the way of building of passenger cars and their supporting structures has been significantly changed and improved. This is particularly evident in the last 25 years. Through the development of steel alloys, aluminium alloys and new plastic materials, the new principles of building self-supporting structures of the car were enabled, regardless of whether it is a self-supporting car body, "SpaceFrame" structure or self-supporting "monocoque" structure. The principles of building of supporting structures or complete car bodies in relation to the applied material are just listed here:

- Steel: mainly conventional self-supporting car bodies and seldom SpaceFrame car bodies
- Aluminium: seldom conventional self-supporting car bodies and mainly SpaceFrame car bodies
- Plastics and composites: mainly monocoque structure

- Multi-material concept, Steel/Aluminium/Plastic and composites in conventional self-supporting, SpaceFrame or in combination with monocoque bodies, too.

Parts production

Production of automotive structural parts has considerably developed in the last two decades, through completely new forms of design, but also through improvement of long known technologies. This is the case with "Hydroforming" technology, which has been known for more than 100 years, but only now is complemented with technological procedures to enable the development of stable and lightweight parts of the supporting structures. Current and new technologies in the production of parts are listed here:

- Conventional (stamping parts - mainly all steel cars)
- Hydroforming (Tubes, sheets), (A-Pillar BMW, B-Pillar Ford, rollover bar many cars, etc.)
- Heatforming (Tubes) (Al-structural part at Ferrari 458 Italia)
- Superplastic Forming (Aston Martin Vanquish, Morgan Aero 8, Mercedes SLS, etc.)
- Tailored blanks, Tailored tubes, Patchwork Blanks (many steel cars)
- Al - extruded profiles (many Al-cars)
- St - roll profiles (in development, Project ATLAS 2002)
- Tailored Strips Technologies (in development, ThyssenKrupp 2012)
- Electromagnetic pulse Technology (for suspension, in development in body).

Joining technology and connection methods

Spot welding at steel car bodies has dominated for the last hundred years. It has even been used for the three-year period (from 1953 to 1956) in the production of the first mass production car made of aluminium sheets (Panhard Dyna Z1). Main technologies and methods used for joining the parts of a supporting structure or car body are listed here:

- Spot welding (conventional method - at many steel cars)
- Laser welding (different systems at many steel and aluminium cars)
- Laser brazing (many steel cars)
- Adhesive joining (many steel and aluminium cars)
- Self piercing rivets (many aluminium cars)
- Clinch-spots /Clinching (many aluminium cars)
- FDS - Flow Drill Screws (many aluminium cars - Audi, Mercedes, etc)
- Tack impact (Mercedes SL)
- FSW - Friction Stir Welding (Ford GT40 and Mercedes SL)

Available materials

It is well known how the car bodies of large series cars were made about two decades ago. The car body was generally built from sheets having single quality of steel and different thickness. Today, in a modern car body or supporting structure, a large number of different materials and different wall thicknesses (sheet, profile or cast) is implemented, so, at the loaded locations, there is as much material as is necessary, and, at unloaded locations, material is reduced. In this way, the basic principle of lightweight design is fulfilled. All this enables a large number of new materials and countless number alloys to be used in modern cars (Figure 7). New kinds of plastics and composites must also be accounted for here (a lot

of new steel and aluminium alloys and new plastics and composites). Despite all this, it must be recognized, that steel, which has been improved and optimized thanks to the research projects of large steel producers, still dominates the large-scale production (Figure 8). Thus, they have contributed to a high quality, efficiently used mass (weight) and safety of new steel supporting structures or car bodies.

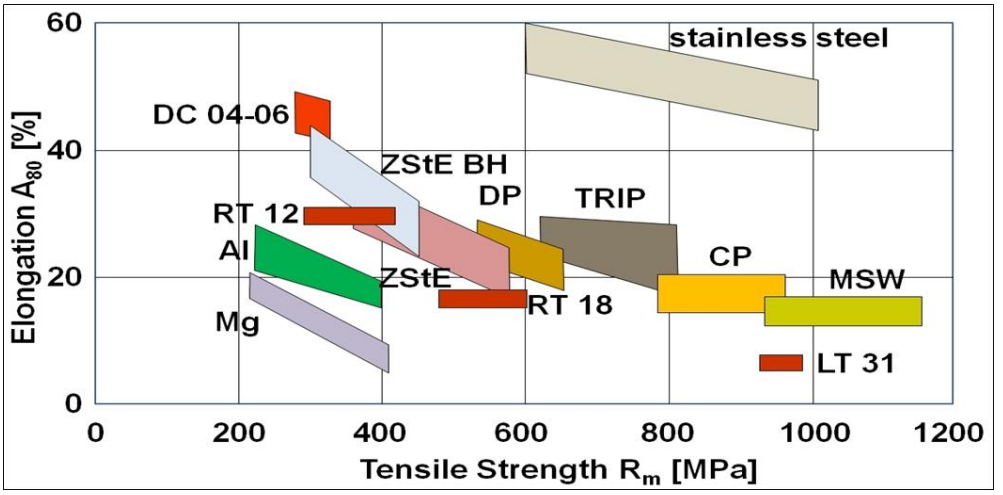

Figure 7 The properties of metallurgical classes of steel, aluminium and magnesium [8]

MAJOR DEVELOPMENT PROJECTS OF STEEL BODYWORK

Major development project of steel bodywork are:

- ULSAB - Ultra Light Steel Auto Body 1996 (Consortium, 35 steel producers, 18 States)
- ULSAB AVC 2002
- Project „ATLAS“ (Salzgitter/Karmann) 2002
- ArcelorMittal „ABC“ project 2004
- Benteler „PG-structure“ 2008
- ThyssenKrupp „InCar project“ 2009
- ArcelorMittal „S-in motion“ project 2010

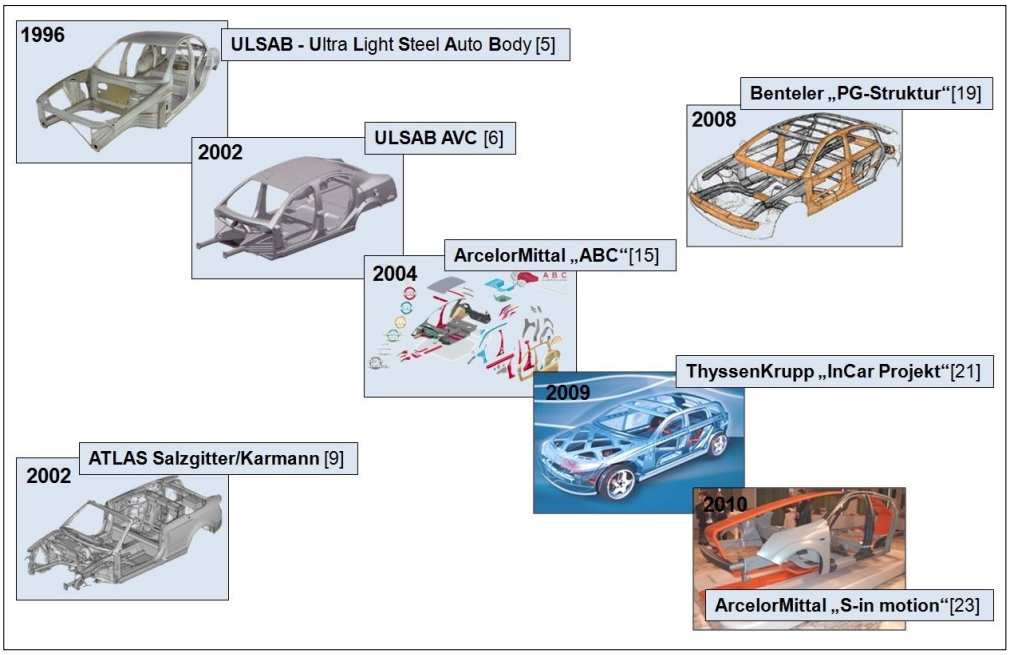

Figure 8 Major development projects of steel bodywork

CONCLUSIONS - NEW VIEWPOINTS FOR THE FUTURE

How did we actually come to the modern car? For years, the car has been developed without respect to man and nature and our intentions were for cars to be stronger, faster, larger and more booted up every day. Thus, a time period may be noticed, during which, with these project goals, the cars had gained big engines and had become not only faster, but also very heavy and large consumers of fuel. Unfortunately, it must be noted, that these cars had not met almost any of today's crash-standards. This period of automotive history has finally stopped and, since July 1992, by introduction of exhaust emissions control (EU emission regulations) and regulations limiting fuel consumption and CO2 emissions per kilometre, has finally been directed. This has led to today's serial production cars whose engines already meet EURO 6 standard. Soon after, standards on passive safety (safety standards) had occurred. It's nice to say that the car bodies of new cars meet these current standards, important for passenger safety. Through a lot of competition in the market, unwritten rules started to apply, on equipping the car with all the known and available serial elements of active safety during steering or manoeuvring the vehicle, as well as elements of passive safety. All this has contributed to the fact that today we drive secure, very efficient (lightweight) as far as weight is concerned, equipped with very "clean" engines and technically functional cars.

It is clear that the premises, on which the cars of the future will be conceived, will be different from the former, and partly present premises and ecological demands and requirements on conservation of energy resources will get priority, which will greatly affect the concept, look and manner of use of future cars. Cars of the future will be strong enough, fast enough and sufficiently dynamic, which means that everything will be in accordance with the electronically strictly controlled roads and highways. In Europe, only in Germany, there are several sections of highways where you can drive without a speed limit. Speed limits are conditioned by the current number of vehicles at any given time on such sections

without speed limits. Given that the world's current number of the passenger cars amounts to about one billion, that there are about 307 million of trucks and about 360 million of motorcycles, and all with a tendency of further growth, it is clear that many things will change in terms of traffic and its regulation. All this indicates that it is more likely that today's way of driving will no longer be possible in the future. Soon, there will be no roads without speed limits and cars will not be able to be controlled individually, but they will have to be harmonized with other participants in traffic, and that would be very tedious for the everyday driver. Considering the existing differences in control skills regarding the car (age differences and speed of reaction), it is clear that electronically driven vehicles will have supremacy in the future, which will significantly increase the traffic safety. The one charm of free driving well known by older generations and longed for by the young, will be unattainable.

We should bear in mind the fact, that the designers of future cars will face the problems that have been neglected so far and those are the types of fuel and total autonomy of movement. The future cars, the ones that will still move on the ground, will lose their specific and individual appearance - it will be cars having functional and unified rational forms, absolutely electronically controlled and managed. The driver will have very little of creative possibilities available when driving.

These considerations can very easily lead to the conclusion that, in the future, there would probably be private category cars, but the possibility of creating the pace and the dynamics of movement and road behavior will not exist. Driving will give the impression that there is a private programmed tram.

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