Bringing a New Car to Market 4

Engineering and Development

Jim Rauf

Steps in Bringing a New Car to Market

Introduction

A little history

Automobile industry

Product Planning-Market Analysis & Identification of Opportunities

Understand market trends, consumer preferences, emerging technologies and government regulations

Analyze competitors - identify gaps in the market for new car

Concept and Design

Translate market insights into conceptual ideas for a new car

Collaborate with design teams and engineers to develop innovative and appealing vehicle concepts

Engineering and Development

Design the vehicle - safety, performance, and efficiency

Extensive testing - prototype testing, crash testing, emissions testing and performance testing

Address any design or engineering challenges that arise during the development phase

Regulatory Compliance

Demonstrate safety , emissions, mileage compliance

Certify models' configurations

BEV mandates

Manufacturing Planning:

Manufacturing plan - consider production volume, assembly processes, and quality control

Identify component suppliers establish partnerships

Set up manufacturing facilities and production lines

Production and Quality Control:

Begin production - ensure adherence to quality standards and specifications

Implement quality control measures - identify and address manufacturing defects

Conduct pre-launch inspections and testing - guarantee the reliability and safety of the vehicles

Launch and Distribution

Marketing campaigns to generate excitement and drive sale

Coordinate with dealerships and distributors to ensure a smooth rollout

Monitor customer feedback - address post-launch issues

Cars are Complicated

Bringing a New Car to Market Engineering Vehicle Design/Styling

The **design/styling phase** is the starting point of automotive **engineering,** where the overall look and functionality of a vehicle are determined

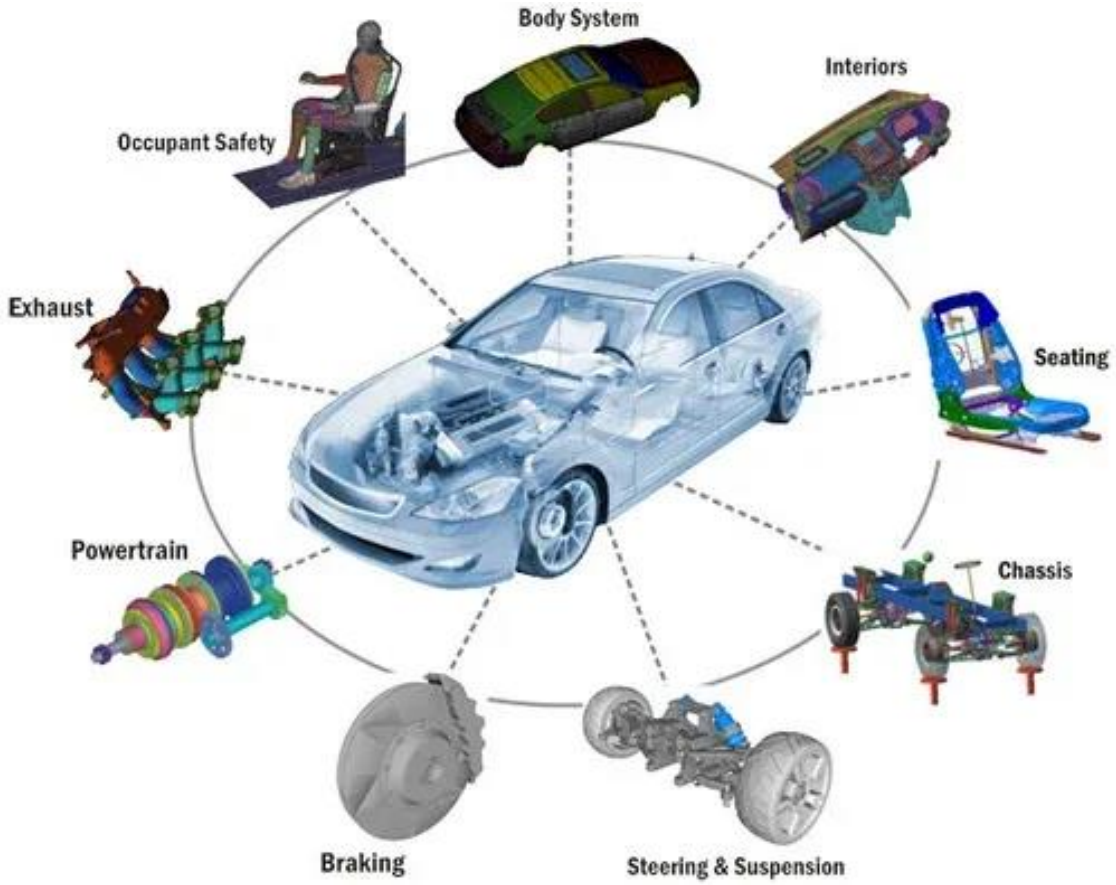
The focus is on creating vehicles that are **aesthetically pleasing** , aerodynamically efficient, safe, and functional

Factors such as **ergonomics**, **interior comfort**, and **exterior aesthetics** are all considered

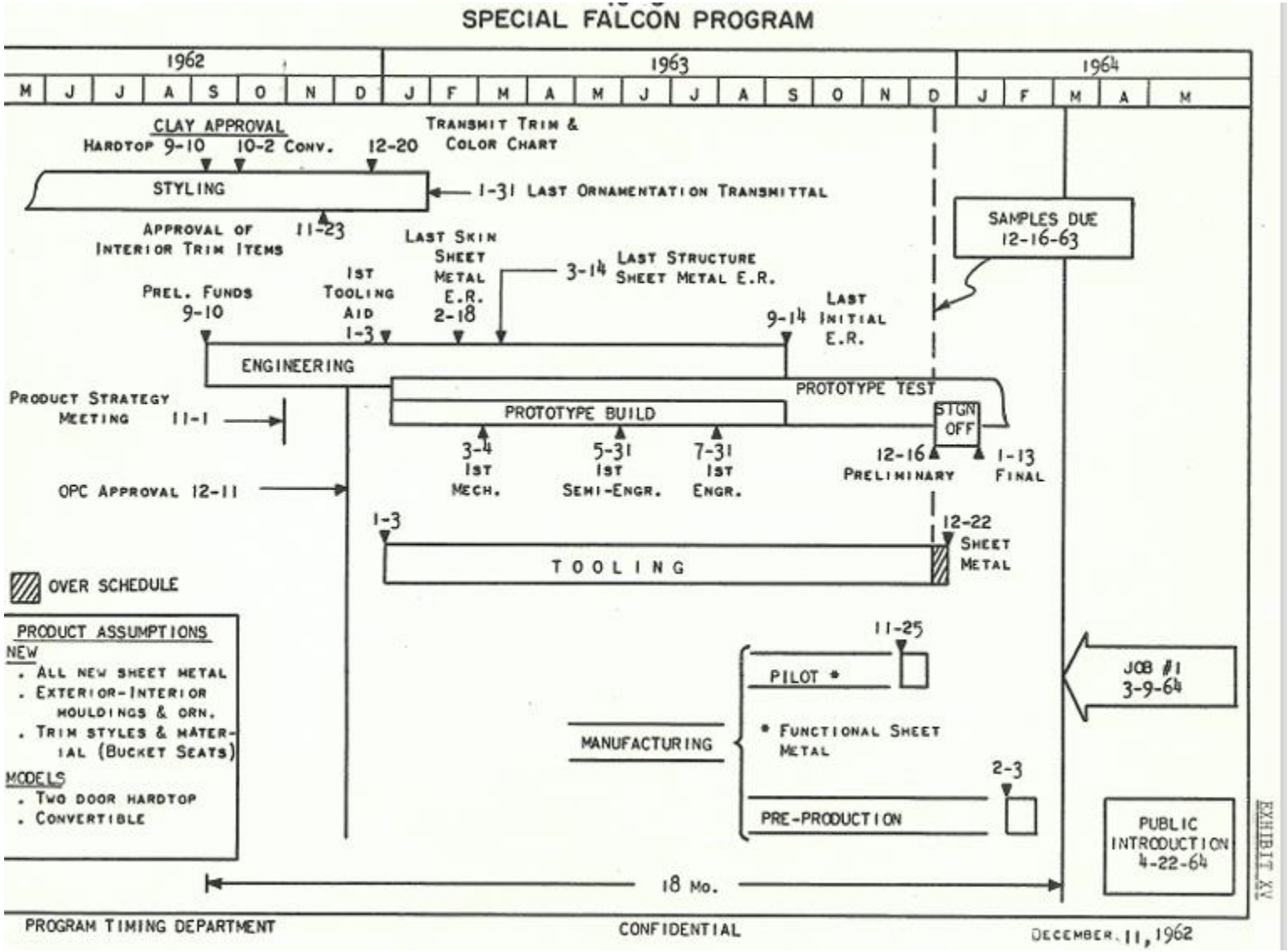
Styling and **functionality** are often not compatible

Engineers and **stylists** have to discuss every inch of the vehicle to bring vision and reality together

Manufacturing engineers assure that styling features can be translated into metal in production



Bringing a New Car to Market Engineering Vehicle Design/Styling



Bringing a New Car to Market Engineering Vehicle Design/Styling

- Engineers work closely with designers to ensure that the aesthetic vision is feasible within the constraints of engineering principles
- They consider factors such as **aerodynamics**, **structural integrity**, **safety regulations**, and **manufacturing processes**
    - Engineers might influence the shape of the vehicle to improve airflow, reduce drag, or enhance crashworthiness
- Engineers help **choose materials** that meet both performance and styling requirements
- They evaluate factors like **strength**, **weight**, **cost**, and **manufacturability**
    - Engineers might suggest using lightweight materials like carbon fiber or aluminum to achieve certain styling goals without compromising performance

- Engineers work with designers to integrate **electronic technology** such as **sensors**, **cameras**, and **displays** into the vehicle's design
    - They ensure that these elements not only function properly but do not disrupt the overall aesthetics of the vehicle
- Engineers optimize various components such as headlights, grilles, wheels, and body panels to achieve the desired styling effects while meeting functional requirements
- Engineers work to ensure that the design can be **manufactured efficiently** and **cost-effectively**
    - They work with designers to simplify complex shapes, minimize tooling costs, and optimize assembly processes without compromising the aesthetic appeal of the vehicle

SAE Automotive Engineering Fundamentals

SAE Thermodynamics of Prime Movers

2.1 Introduction

2.2 Two- and Four-Stroke Engines

2.3 Indicator Diagrams and Internal Combustion Engine Performance

Parameters

2.4 Otto and Diesel Cycle Analyses

2.4.1 The Ideal Air Standard Otto Cycle

2.4.2 The Ideal Air Standard Diesel Cycle

2.4.3 Efficiencies of Real Engines

2.5 Ignition and Combustion in Spark Ignition and Diesel Engines

2.6 Sources of Emissions

2.6.1 Simple Combustion Equilibrium

2.6.2 Unburned Hydrocarbons (HC) and Nitrogen Oxides (NOx) in Spark Ignition Engines

2.6.3 Unburned Hydrocarbons (HC), Nitrogen Oxides (NOx), and Particulates in Compression Ignition Engines

2.7 Fuel and Additive Requirements

2.7.1 Abnormal Combustion in Spark Ignition Engines

2.7.2 Gasoline and Diesel Additives

2.8 Gas Exchange Processes

2.8.1 Valve Flow and Volumetric Efficiency

2.8.2 Valve Timing

2.8.3 Valve Operating Systems

2.8.4 Dynamic Behavior of Valve Gear

2.9 Engine Configuration

2.9.1 Choosing the Number of Cylinders

2.9.2 Balancing of the Primary and Secondary Forces and Moments

SAE Thermodynamics of Prime Movers

Spark Ignition Engines

3.1 Introduction

3.2 Spark Ignition and Ignition Timing

3.2.1 Ignition System Overview

3.2.2 The Ignition Process

3.2.3 Ignition Timing Selection and Control

3.3 Mixture Preparation

3.4 Combustion System Design

3.4.1 Port Injection Combustion Systems

3.4.2 Direct Injection Spark Ignition (DISI) Combustion Systems

3.5 Emissions Control

3.5.1 Development of the Three-Way Catalyst

3.5.2 Durability

3.5.3 Catalyst Light-Off

3.5.4 Lean-Burn NOx-Reducing Catalysts, “DENOx”

3.6.1 Variable Valve Timing and Induction Tuning

3.6.2 Supercharging

3.7 Engine Management Systems

3.7.1 Introduction

3.7.2 Sensor Types

3.7.2.1 Crankshaft Speed/Position and Camshaft Position

3.7.2.2 Throttle Position

3.7.2.3 Air Flow Rate

3.7.2.4 Inlet Manifold Absolute Pressure

3.7.2.5 Air Temperature and Coolant Temperature

3.7.2.6 Air-Fuel Ratio

3.7.2.7 Knock Detector

3.8 Engine Management System Functions

3.8.1 Ignition Timing

3.8.2 Air-Fuel Ratio Control

3.8.3 Exhaust Gas Recirculation (EGR) Control

3.8.4 Additional Functions

Bringing a New Car to Market Engineering Powertrains

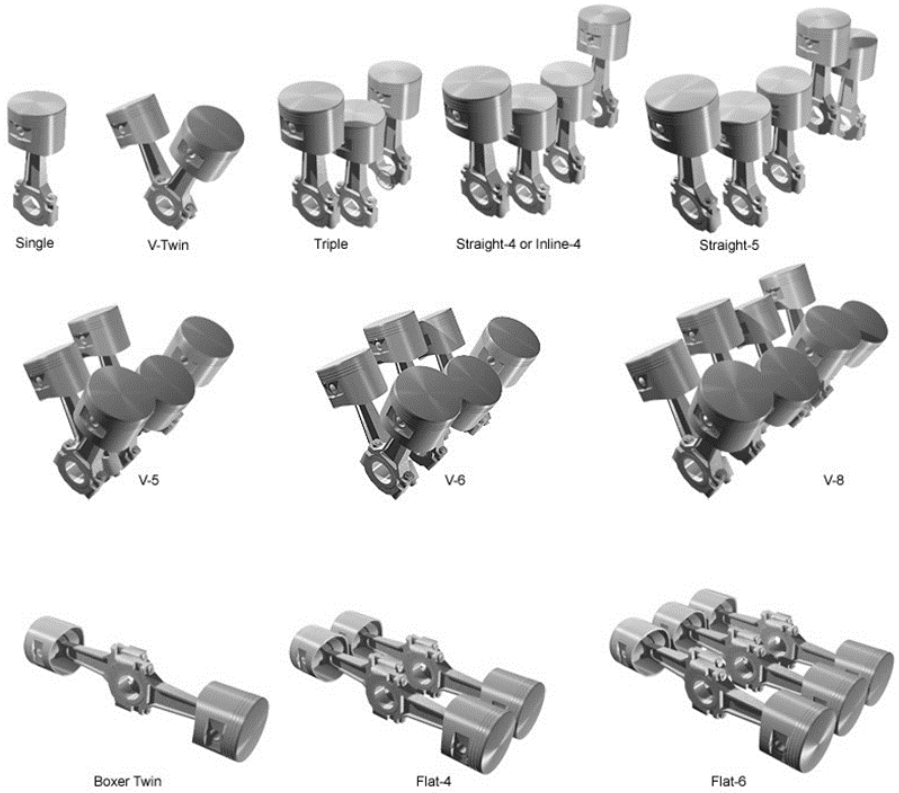
- **ICE** powertrain is the **engine**, **transmission**, and **drivetrain** components - drive shafts , joints, differential ,etc
- Engineers work to develop **powertrains** that balance performance, fuel efficiency, and emissions
- **BEV** powertrain is **electric motor**(s), **transmission,** and drivetrain components –drive shafts , joints, differential, etc

- Engineers assess the desired **performance characteristics** of the vehicle , including **power output**, **torque**, and **acceleration**
- Goal is to **balance performance** with **fuel efficiency** to meet regulatory standards and customer expectations
- Engineers evaluate the overall cost-effectiveness of the engine, considering factors like manufacturing complexity, materials, and technology required
- The engine must be compatible with the vehicle platform, considering factors like **size**, **weight**, and **mounting points**
- The engine choice should **align with the brand image**
- **Consumer preferences** can influence decisions regarding traditional **internal combustion engines**, **hybrids**, **electric vehicles**, or **alternative powertrains**

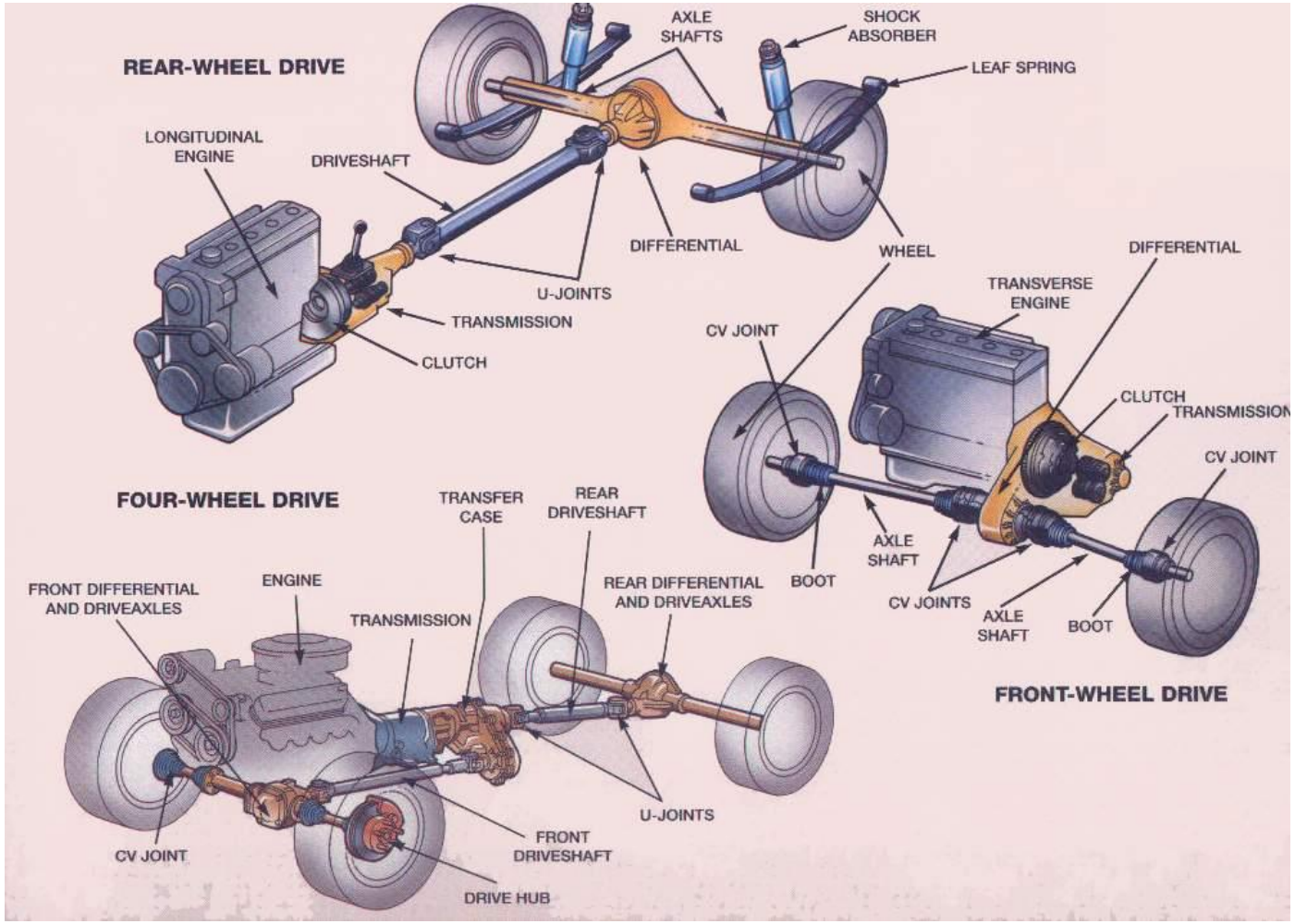
Bringing a New Car to Market Engineering Engines

- **Internal Combustion Engines (ICE)**
- **Spark ignition –Gasoline fuel**
  - **Otto cycle-4 stroke**
  - **Atkinson/Miller cycle – 4 stroke**
- **Compression ignition – Diesel fuel**
  - **Diesel cycle**
- **Hybrid**
  - **ICE and electric**
- **Plug in hybrid**
  - **ICE and battery**
  - **Charging capable**
- **Battery electric (BEV)**
  - **No ICE**
  - **Fully electric**

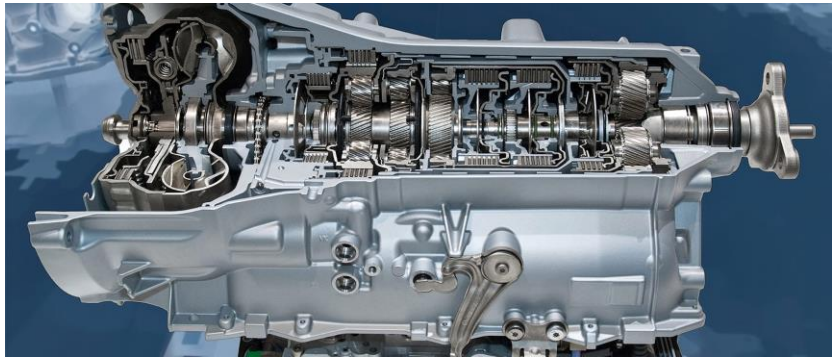
- **IC engine configurations**
  - **3 cylinders I-3**
  - **4 cylinders I-3 I-4**
  - **5 cylinders I-5**
  - **6 cylinders I-6 V-6 H-6**
  - **8 cylinders V-8**
  - **10 cylinders V-10**
  - **12 cylinders V-12 W-12**
- **Induction system**
  - **Normally aspirated**
  - **Super charged**
  - **Turbo charged**



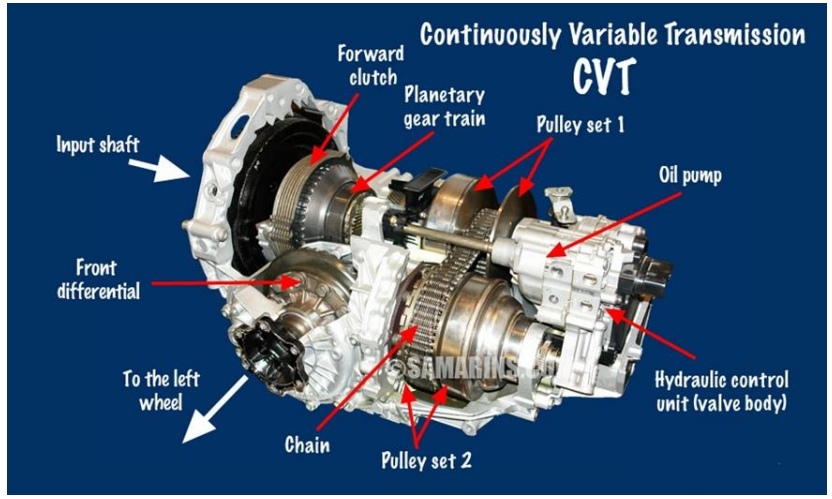
Bringing a New Car to Market Engineering Powertrains

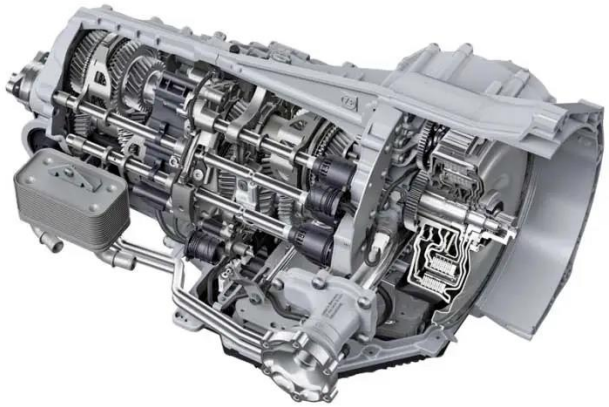


Bringing a New Car to Market Engineering Transmissions

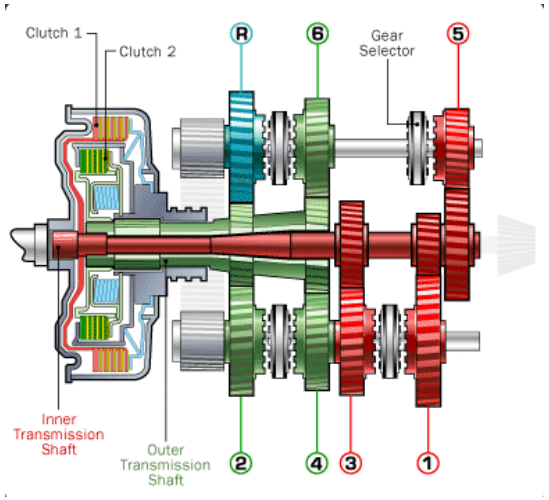


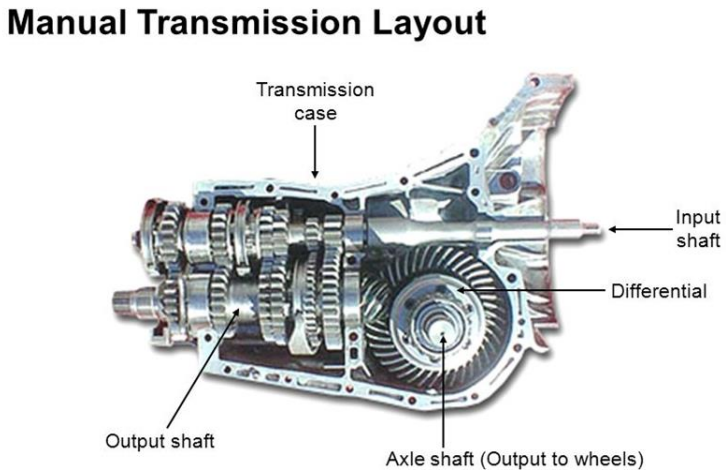
Automatic Transmission





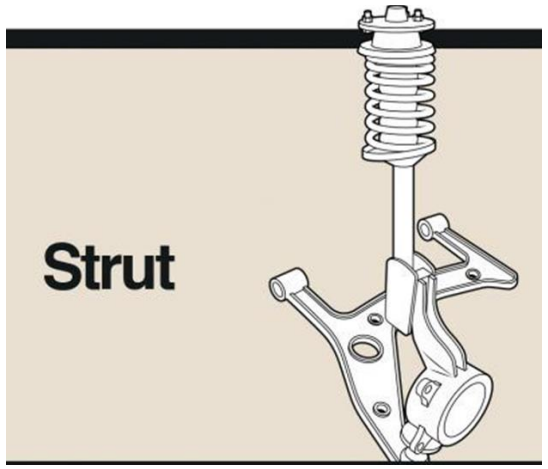
Dual Clutch Automatic Transmission

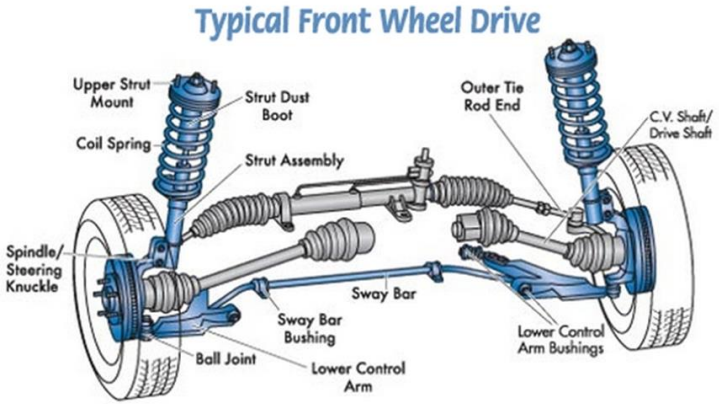


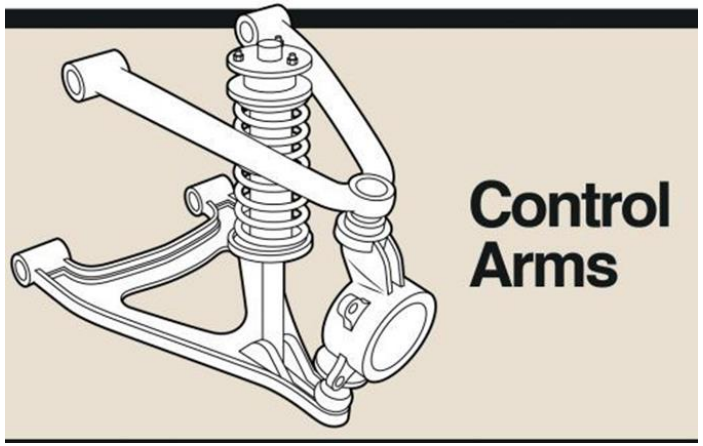


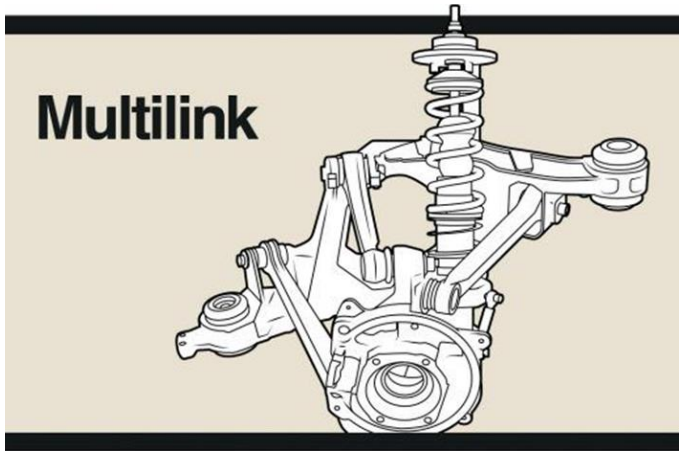
Bringing a New Car to Market Engineering Suspension- Steering- Brakes

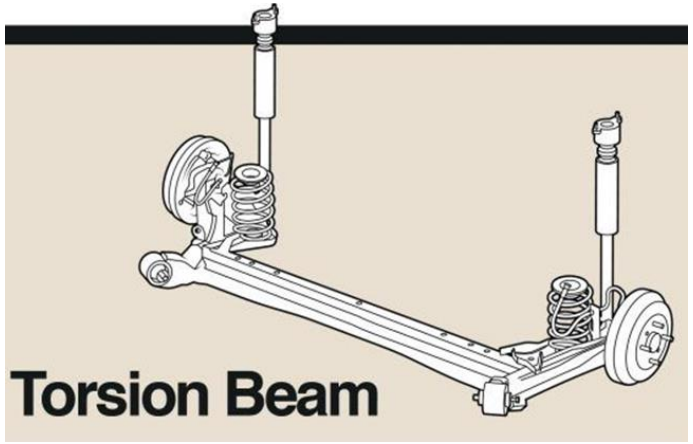
- **Vehicle Dynamics and Handling:**
- Optimal vehicle dynamics and handling characteristics are crucial for safety and driving pleasure
- Engineers select **suspension**, **steering**, and **braking systems** consistent with the targeted driving characteristics of the vehicle
- They fine tune these systems to ensure stability, comfort, and control on various road conditions
- **Spring rates** and **damper(**shock absorber) settings are selected based on **brand identity**

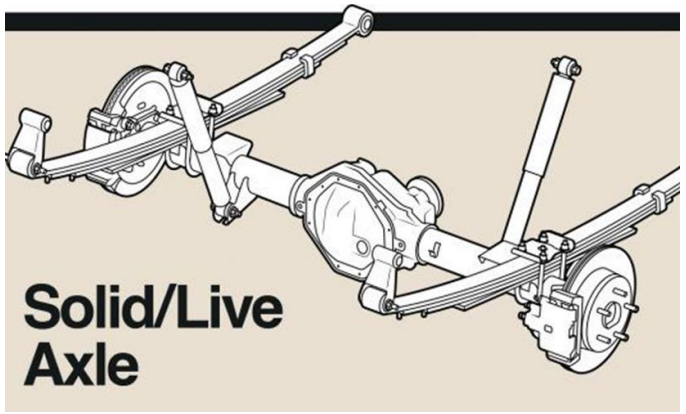

Strut


Typical Front Wheel Drive
Upper Strut Mount
Strut Dust Boot
Outer Tie Rod End
C.V. Shaft/ Drive Shaft
Coil Spring
Strut Assembly
Spindle/ Steering Knuckle
Sway Bar
Sway Bar Bushing
Lower Control Arm Bushings
Ball Joint
Lower Control Arm

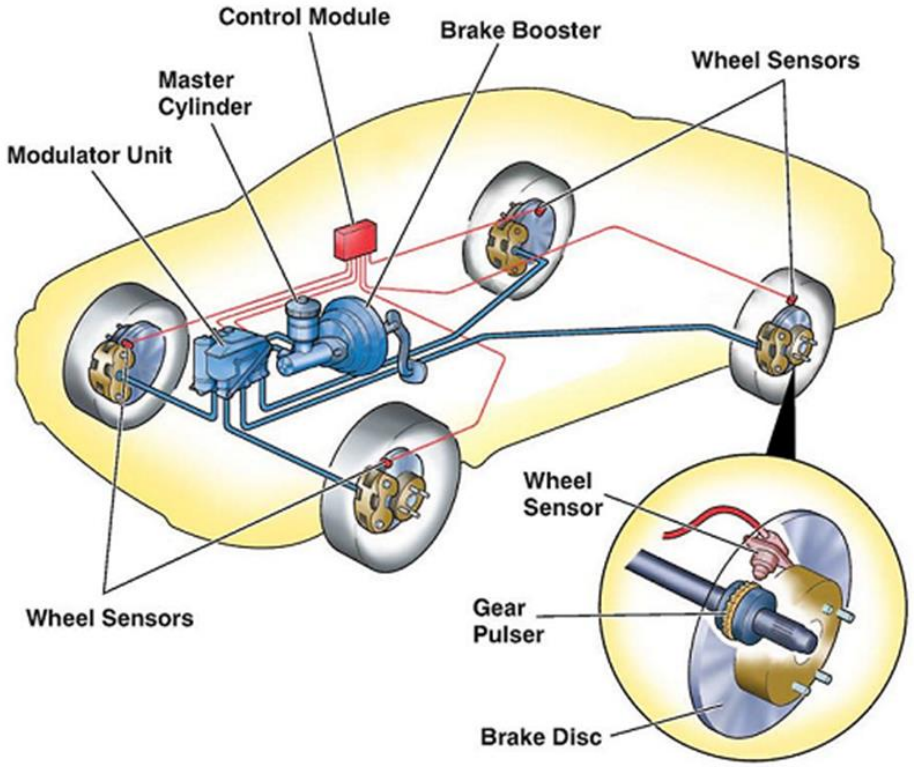

Control Arms


Multilink

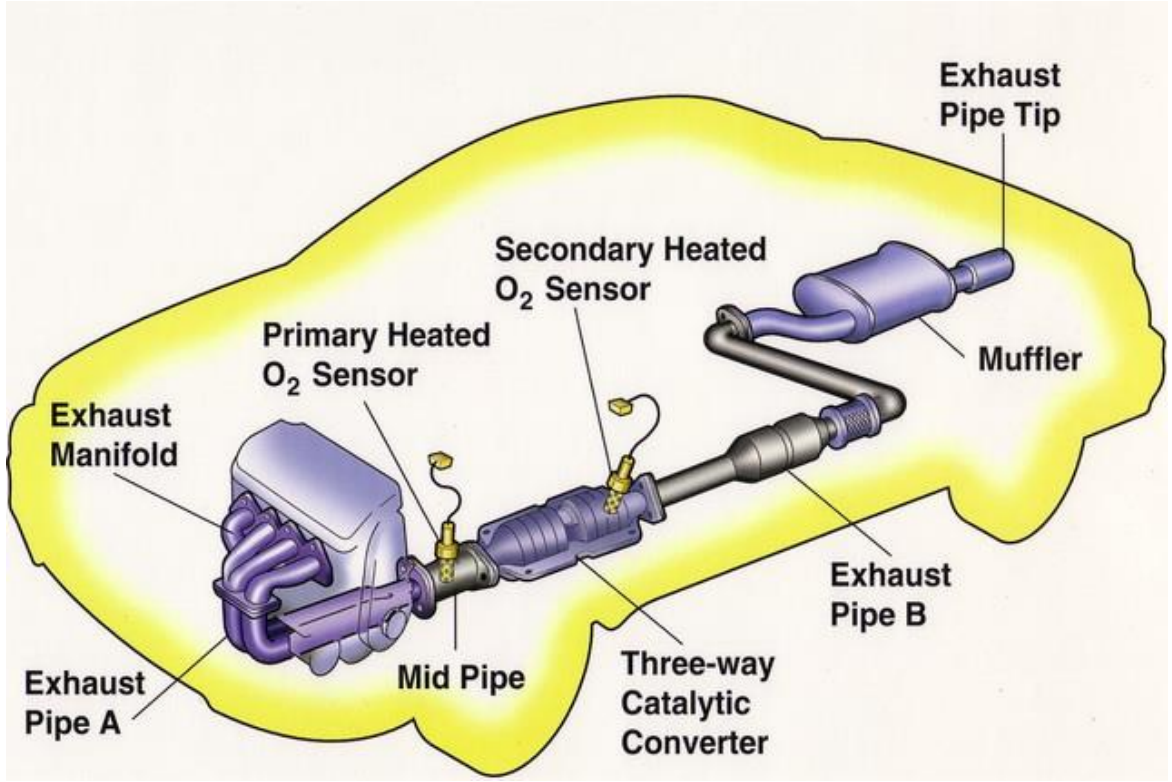

Torsion Beam


Solid/Live Axle

Bringing a New Car to Market Engineering Suspension- Steering- Brakes

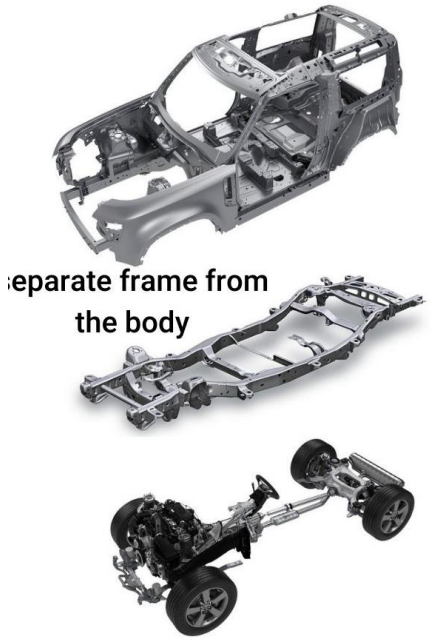


- The **exhaust manifold** is the first component of the exhaust system. It contains a stainless steel, cast- iron or aluminum unit that joins with the engine's combustion cylinders
- The **muffler** contains a series of baffles that help in dampening the noise of the engine gases and the engine combustion
- The **catalytic converter** prevents harmful pollutants like nitrogen oxides and carbon monoxide from escaping into the environment
- The piping connecting exhaust system components is a steel or stainless steel pipe
- **Oxygen sensors** in the exhaust system send signals to the **IC engine** control unit to maintain proper fuel flow



Bringing a New Car to Market Engineering Structure

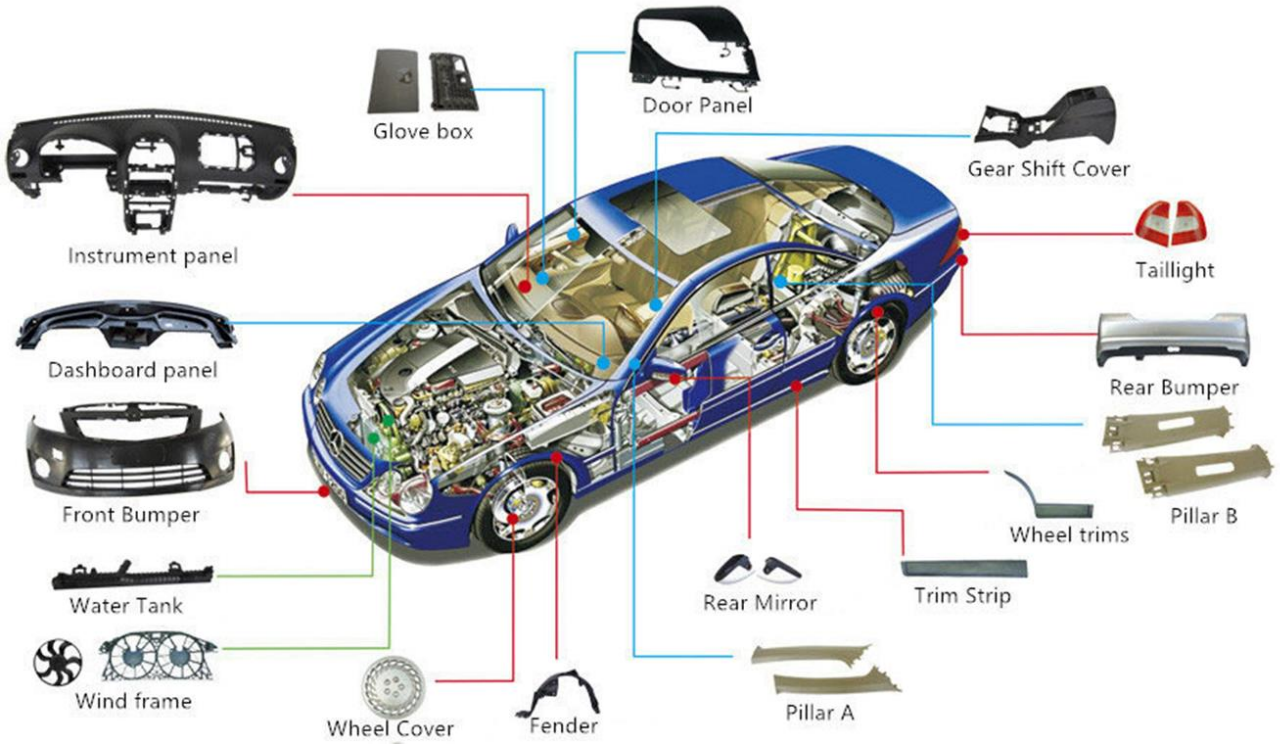
- **Body-on-frame**
- The vehicle body is built on a relatively rigid frame
- The frame supports the drivetrain and the engine
- The Body-on-Frame is easier to design, repair, and is less likely to suffer damage from rust
- This design is heavier and has higher center of gravity



- **Unibody Frame**
- In this frame, both functions are met in the same assembly
- Its success among the others, is due to its lightness
- Even popular midsize SUV's, have acquired the unibody frame construction
- The monocoque or unibody construction has reached the state of art in the automobile manufacturing
- Is so sophisticated that the **windshield** often makes a significant contribution to the vehicle's structural strength

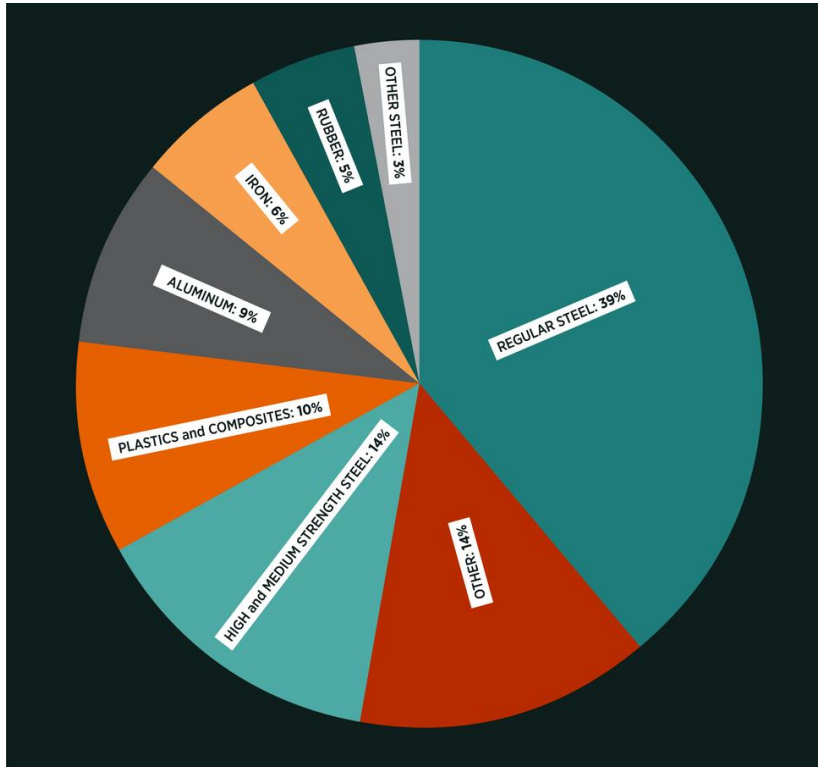
Bringing a New Car to Market Engineering Materials and Manufacturing

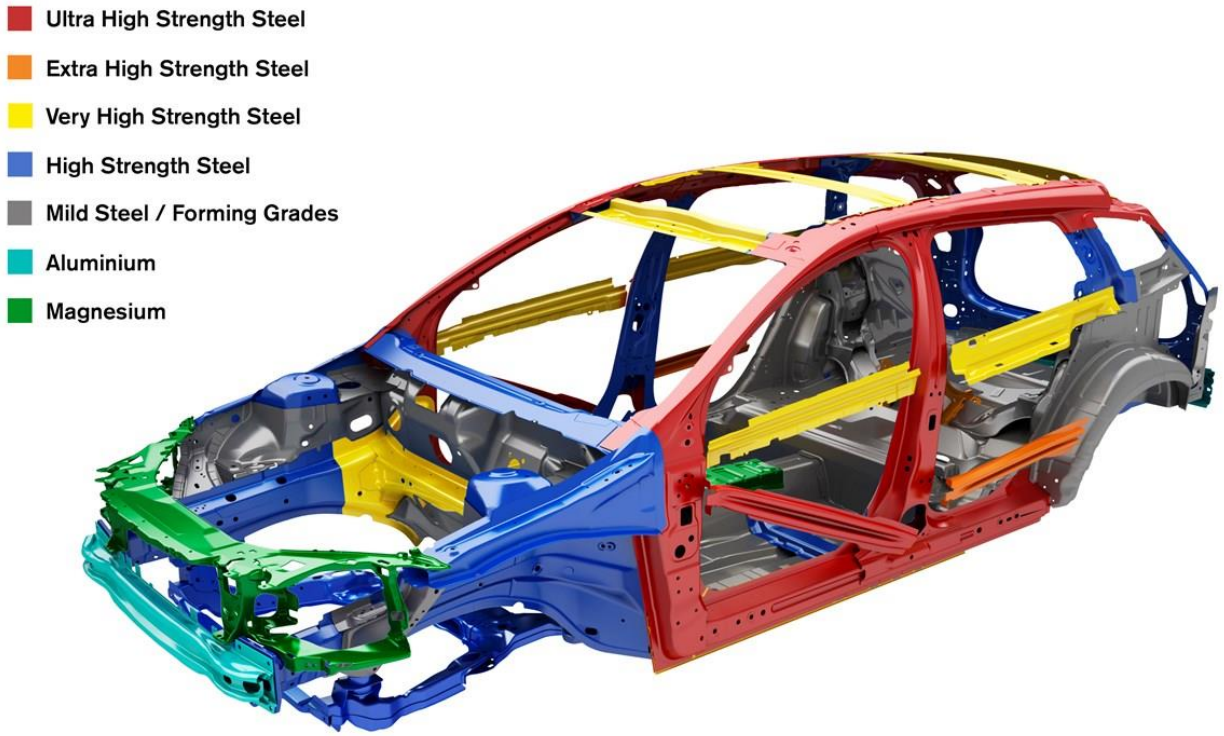
- Selecting the right **materials** and **manufacturing processes** is essential to building reliable and cost-effective vehicles
- Cars use a wide range of materials, from lightweight alloys to advanced composites, to optimize strength, durability, and weight
- A variety of materials is used in different parts of a vehicle to achieve desired strengths, weight and costs



Bringing a New Car to Market

Engineering Structure Materials

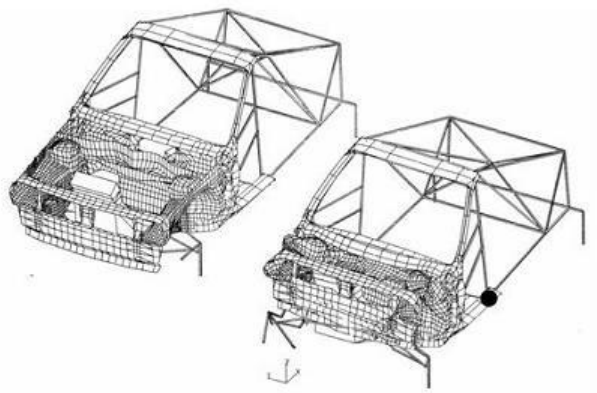




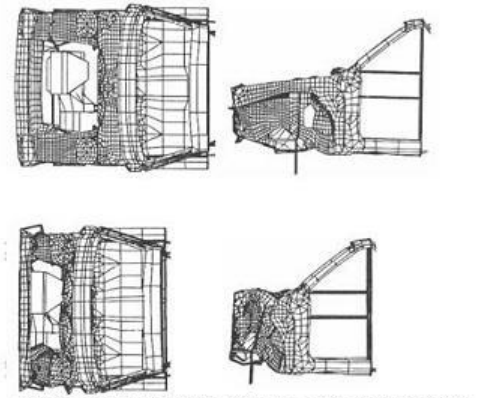
Bringing a New Car to Market

Engineering Crashworthiness

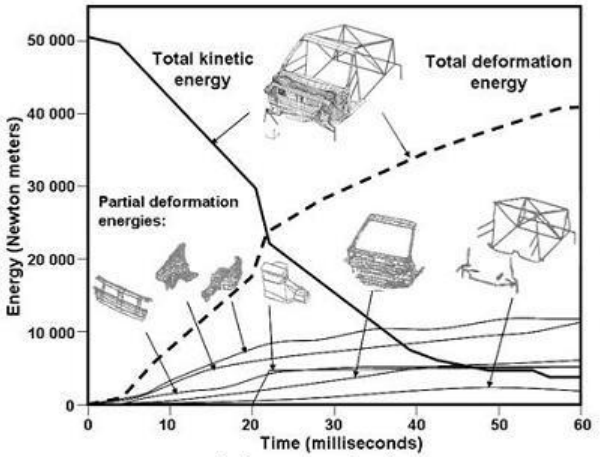
- Engineers employ crash-test **computer simulations** and **advanced materials** to design vehicles that protect occupants in the event of a collision
- Features like **airbags**, **crumple zones**, and **advanced driver-assistance systems (ADAS**) contribute to vehicle safety
- Safety features must satisfy regulatory requirements and be demonstrated by actual **vehicle testing**



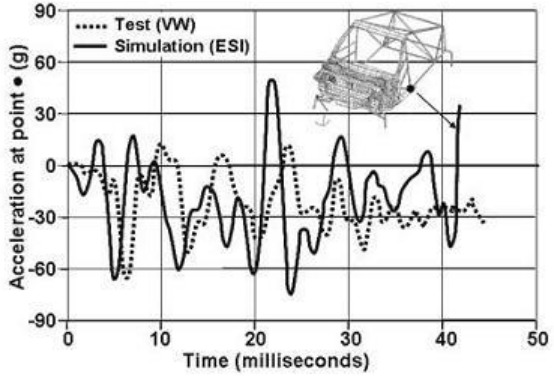
(a) crash simulation



(b) top and side views of simulation



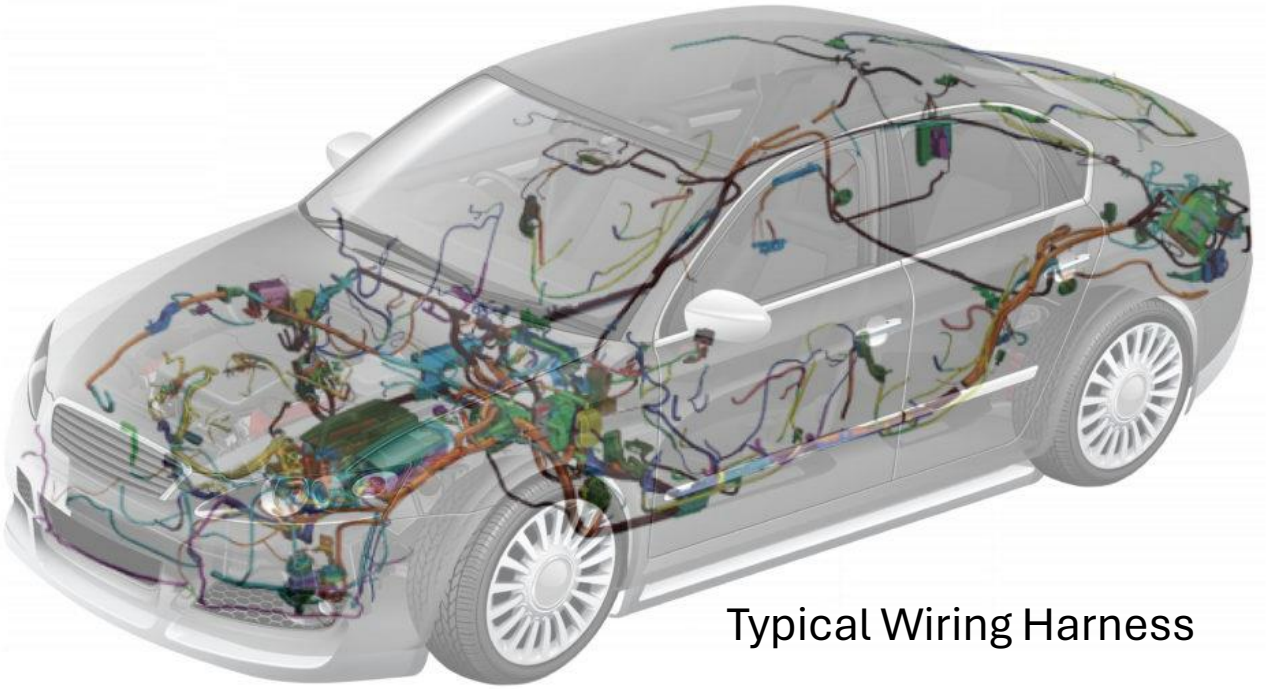
(c) energy balance



(d) acceleration at point in cabin

Bringing a New Car to Market Engineering Electrical , Electronic Systems

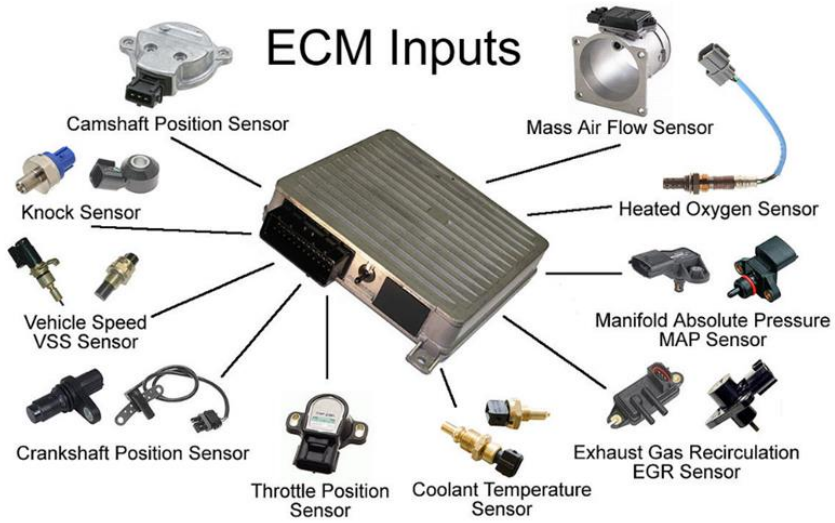
- Engineers develop a number of **vehicle electronic systems**
- **Engine** , **transmission** and **suspension system** controls
- **Infotainment systems** to enhance the driving experience
- Systems to **improve fuel efficiency**
- **Driver alert** safety systems
- Systems provide **connectivity options**
- Many of these electronic systems must be integrated into the vehicle structure

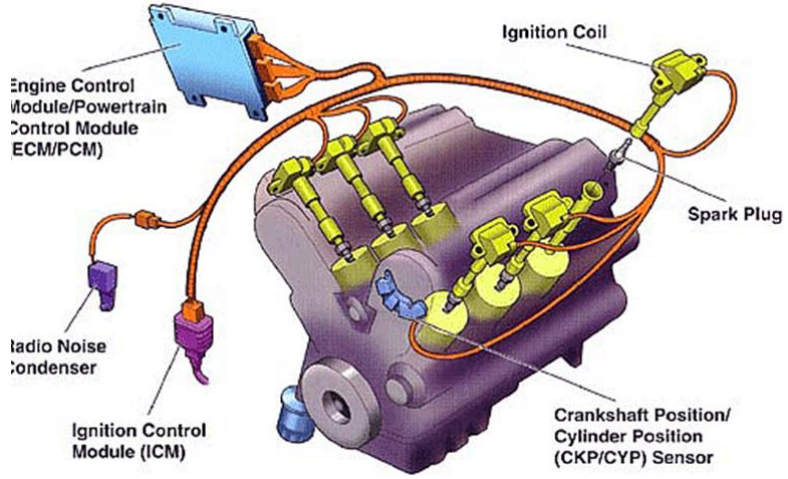


Typical Wiring Harness

Bringing a New Car to Market Engineering Electrical , Electronic Systems

- The **ignition system** is used to create and deliver a spark discharge to the spark plugs of an ICE
- The **engine starting system** creates a certain rotational speed of the crankshaft.
- The **lighting** and **signaling system** operates the front and rear lights, turn signals, fog lights, and marker lights, instrument and interior lights
- **Electronic control units (ECU)-** a computer that controls multiple systems in the vehicle:
    - Engine , suspension, braking systems





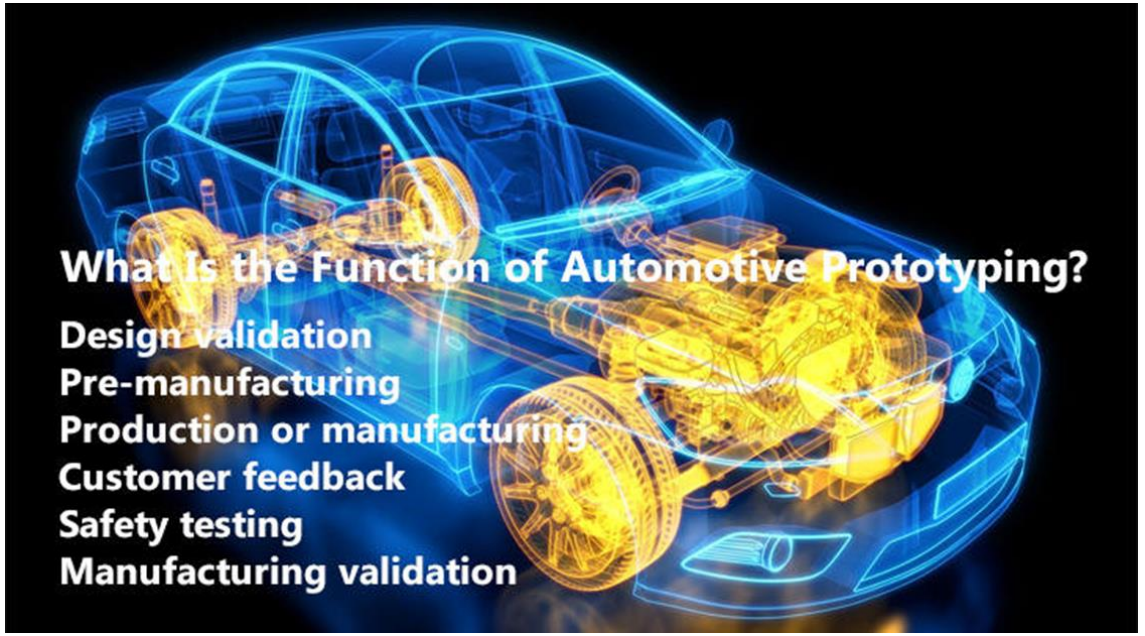
Bringing a New Car to Market

Manufacturing Engineering

- **Manufacturing engineering** deals with functions required to build, assemble, test and ship new cars
- Process and assembly development
- Logistics and materials planning
- Tooling design
- Test design and development
- Robotics
- Manufacturing Systems
- Production/Final assembly test
- “Fixing’ problems during production

Bringing a New Car to Market Engineering Testing

- Thorough testing and validation are essential to ensure a vehicle meets safety (crash tests) and general performance standards
- Engineers conduct extensive testing, both in laboratories and real-world scenarios, to identify and rectify issues
- They test components and prototype vehicles
- In addition to crash testing, automakers target numerous other quality measurements



Bringing a New Car to Market Engineering Testing

Bringing a New Car to Market Engineering Testing

- How noisy is it inside the cabin?
- How much noise comes from the engine?
- What is causing squeaks and rattles?
- How much noise is created by tires contacting the pavement?
- How much vibration is there at different speeds?
- How fast does the air conditioning system or heater kick in?
- Does the quality and luxury match other products in this brand?
- Does it equal or exceed competitive offerings?
- Are we meeting our own standards for brand expectations for the car are?

- What drivetrain combination will give us optimal fuel efficiency while satisfying emissions requirements?
- How do we reduce weight and waste without compromising safety or comfort or quality?
- How does the car perform in extreme conditions?
- Depending on what's being tested, engineers can make changes immediately to designs but in other cases, test findings may require an extensive rethinking of how a part or set of parts functions in order to develop the most appropriate solution to address the discovered issues
- To make sure the entire testing process stays reasonably on schedule, manufacturers make multiple "test mules," or pre-production cars, for testing

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