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An Overview of 8 Topics and How They Might Have Affected the Design/Development of the 2017 Ford GT.

Introduction to Automotive Engineering (ACHA4009)

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1. Introduction

This report will delve briefly into 8 separate topics and will analyse and discuss how each of these 8 topics affected the production and development of the 2017 Ford GT, after which there will be a segment on how the car fits into the current landscape of the industry considering all changes to laws, attitudes and such.

2. Impact of the Following Topics

2.1. Materials.

The 2017 Ford GT was produced using a variety of exotic materials and lightweight composites that include a special lightweight aluminium that was developed by Ford following its investment in aluminium chassis development, which will be used to construct ultra-lightweight front and rear subframes. The 2017 Ford GT also features an integrated steel roll cage to improve structural rigidity and safety. The car's passenger cell (below) is made entirely of Carbon Fibre as well as the whole main body of the car being made of carbon fibre, which is a major factor that contributes to the amazing structural rigidity of the car, whilst simultaneously reducing the overall weight. (*FORD GT specs & photos - 2017, 2018, 2019 - autoevolution*, no date; *New Ford GT will offer five adjustable drive modes | evo*, no date)



Figure 1: Carbon Fibre Passenger Cell of the 2017 Ford GT. (6 Just-Revealed Secrets About the 2017 Ford GT, the Most Anticipated Supercar of the Decade - Maxim, 2017)

The 2017 Ford GT also has Carbon Ceramic Brakes, which is not uncommon in high performance cars today, it is highly desirable compared to their cast iron alternatives, least of which being that Carbon ceramic discs are approximately 50% lighter, also having improved brake responsiveness, Carbon ceramic withstands a higher coefficient of friction without resulting in brake fade, better directional stability, not to mention its corrosion and wear resistance accompanied by the fact that it produces far less brake dust. (*Brake-technology | SGL Carbon*, no date; *6 Just-Revealed Secrets About the 2017 Ford GT, the Most Anticipated Supercar of the Decade - Maxim*, no date)



Figure 2: 2017 Ford GT's Brembo carbon ceramic brake disc. (Brembo på Twitter: "The #Brembo brake of the #Ford GT? Here's how they look like! #carbonceramic #theartofbraking <https://t.co/n2Vqyo6iQN>" / Twitter, no date)

2.2. Manufacturing.

Ford have not disclosed the complete manufacturing process of the 2017 Ford GT; however, some light can be shed to the manufacturing process of Ford's Ecoboost Engines. Ford state that their ecoboost engines are made of aluminium, which saves weight and therefore fuel economy, nevertheless an engine is still expected to deal with High wear conditions, thermal stresses and fatigue strain. As stated by (Nguyen, 2005), "the required mechanical properties for a typical aluminium engine block includes an ultimate tensile strength of 245 MPa, yield stress of 215 MPa, and fatigue strength of 60 MPa" (MPa = Megapascal Pressure Unit). In terms of the manufacture of cylinder blocks, there are primarily two different Aluminium alloys that are used in construction of cylinder blocks, which are known as Aluminium 319-T5 and Aluminium A356-T6.

Table 1: Comparison of Tensile strength (MPa) and Elasticity (GPa) between Aluminium Alloys 319-T5 and A356-T6. (Nguyen, 2005)

	Aluminium Alloy 319-T5	Aluminium Alloy A356-T6
Tensile Strength, MPa	178	215
Elasticity, GPa	74	72.4

These Engine blocks are usually made with sand casting, this would be done by sand moulding. Sand moulds are typically made with "Zircon sand, glue and a hardener" as mentioned by (*How Is an Engine Block Made?*, no date). After the mould has been made, the metal, in this case aluminium alloy, is superheated to 800°C and poured into the mould in which it will then cool, and henceforth hardening and setting. Once the alloy has set in the mould, the mould is then heated in order to break down the sand, leaving the cast engine block. After this the cast engine blocks are machined and inspected.



Figure 3: 3.5L Ecoboost V6 Engine ((197) Pinterest, no date)

2.3. Dynamics and Kinematics.

(*New Ford GT Suspension - 2017 Ford GT's Chassis Design*, no date) The Ford GT's suspension can best be described as a Double wishbone pushrod actuated torsion bar system, which work in tandem with two coil springs set up on top of one another. This elaborate suspension setup has allowed Ford to move the suspension inboard, which clear space for the giant aerodynamic features on the car.

1 = Coil Springs and Hydraulic Actuator

2 = Torsion Bar

3 = Rocker

4 = Electronically controlled Spool Valve Damper

5 = Pushrod

6 = Lower Control Arm

7 = Upper Control Arm

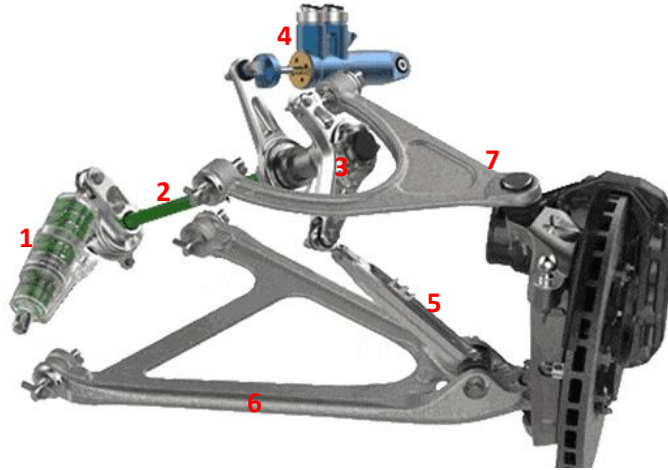


Figure 4: 2017 Ford GT Suspension setup. (*New Ford GT Suspension - 2017 Ford GT's Chassis Design, no date*)

As can be observed in Figure 4 (above), Connected to the lower control arm (6) is a pushrod (5), during suspension travel this pushrod moves up, hence rotating to rocker (3) which is connected to the electronically controlled spool valve damper (4). After the pushrod moves up, the rocker turns, which then turns the torsion bar (2), which acts as the first spring of the car. Connected to the end of the torsion bar is another rocker which is connected then to a set of coil springs (1) which act as the second spring of the car. It is also worth mentioning that this set of springs, which are mounted on top of one another, this means that they take half the force to compress in comparison to a conventional spring, meaning the spring rate is halved.

When the drive modes labelled 'Vmax' or 'Track' are selected, one of the two springs locks up completely, which effectively doubles the spring rate, and the ride height drops by almost 2 entire inches, which lowers the ground clearance to 2.75 inches (70mm).

2.4. Control Systems.

The Electronic systems in the 2017 Ford GT were designed, developed and manufactured by a British Company called Pektron, who were responsible for the innovative electronic systems such as the information cluster, damper controllers and vehicle dynamic systems.

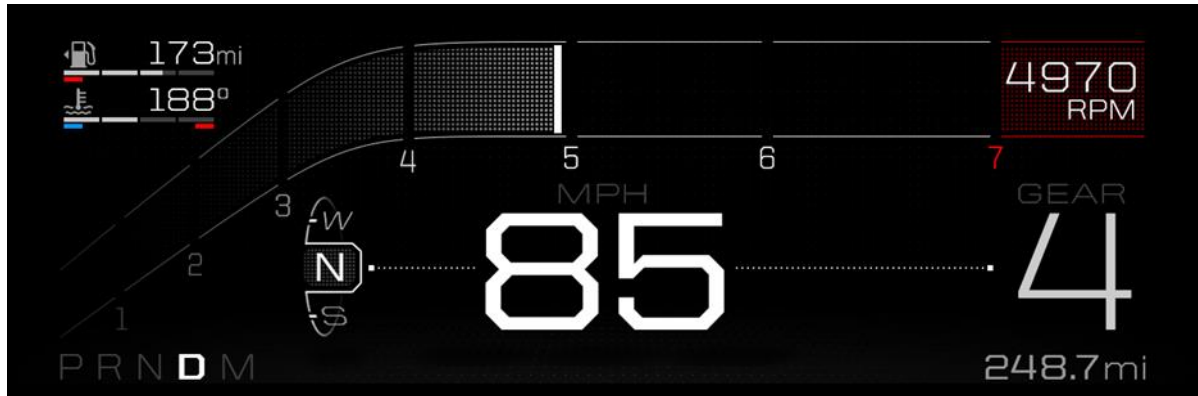


Figure 5: Electronic Driver Information Cluster in "drive mode" 2017 Ford GT. (The Ford GT's Digital Gauge Cluster Makes it Easier to Go Fast » AutoGuide.com News, no date)

The electronic damper control detects whatever drive mode is currently selected and alters the suspension system to accommodate for that driving mode's setting. The digital driver information cluster is also controlled according to drive to display the most relevant information for that mode, in figure 5 (above), the instrument cluster is in "Drive" and therefore displays information pertinent to road driving.

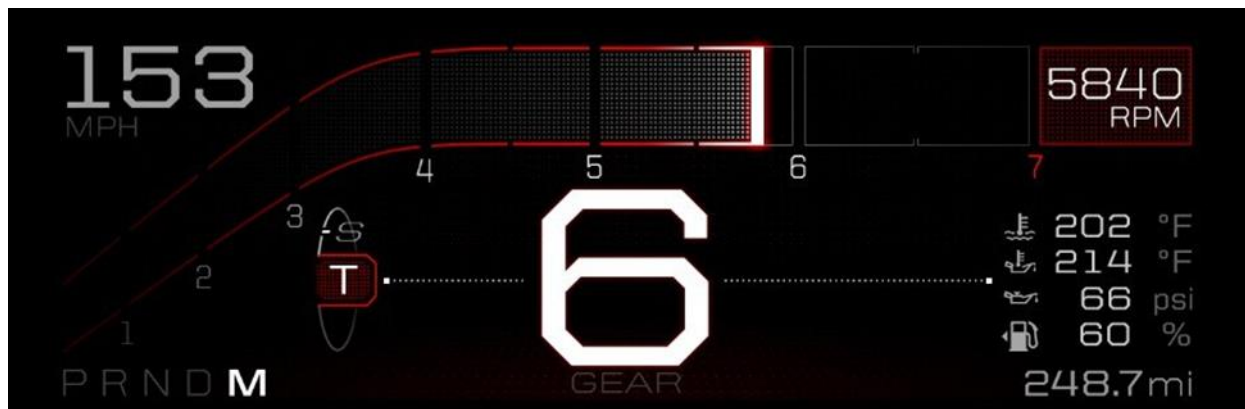


Figure 6: Electronic Driver Information Cluster in "Track" mode in 2017 Ford GT. (All-New Ford GT Supercar's Digital Instrument Display Is The Dashboard of the Future | Ford Media Center, no date)

On Figure 6 (above), the Driver information cluster is in "Track" mode, and therefore displays the information most valuable to the driver when in a track driving or race scenario such as the rev meter and gear display. Speed is moved to the top left of the cluster. (Pektron electronics on new Ford GT supercar, no date)

2.5. Emissions.

Emissions of the 3.5L EcoBoost V6.

For the entirety of the EPA FTP75 drive cycle, over 80% of the Hydrocarbon (HC) emissions occur in the initial 20 seconds of the cold start. Furthermore, optimisation of the cold start process is challenging due to the variety of opposing factors at play, such as the fast-changing engine speed, low fuel pressure and cold thermal environment. One partial solution outlined by (Xu *et al.*, 2009) is to retard the spark time so that the combustion generates higher heat fluxes and therefore the catalytic converter would reach operating temperature faster, but this comes with its own myriad of issues due to the degradation of combustion stability.

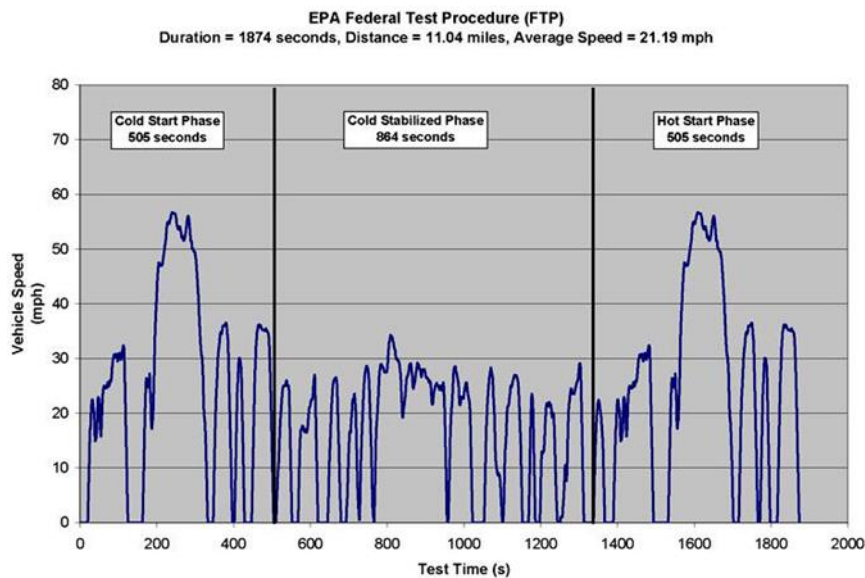


Figure 7: EPA FTP75 Drive Cycle.(EPA Federal Test Procedure (FTP) | US EPA, no date)

Ford have their own in-house developed CFD (computational Fluid Dynamics) code MESIM (Multi-Dimensional Engine Simulation) which they used to investigate the effects of “injection parameters and piston designs on the fuel preparation process”, they conducted these investigations at several engine speeds to better see the effects at different RPM’s (Xu *et al.*, 2009). These experiments concluded that the key element to increasing combustion stability and reducing emissions was “the formation of a robust fuel-air mixture distribution around the spark plug” (FlexPaper AdaptiveUI JSP Example, no date). The factors that they determined influenced fuel-air mixture distribution was fuel pressure, piston bowl design and injection timing. They developed a split-injection system that according to engine test data, did in fact help with fuel-air distribution around the spark plug and subsequently reduce hydrocarbon (HC) emissions.

2.6. Aerodynamics and Engineering Problem Solving.

Considering that half of the LeMans track is constituted by the legendary Mulsanne straight, the aerodynamic design of the car was a very important feature to refine, but in order to do this some problems had to be solved.

Complications and contradictions in engineering can be solved using something called the TRIZ matrix, which collects 40 Principles (which are generally solutions) that are able to overcome the complications and contradictions. (*TRIZ Matrix / 40 principles / TRIZ contradictions table, no date*)

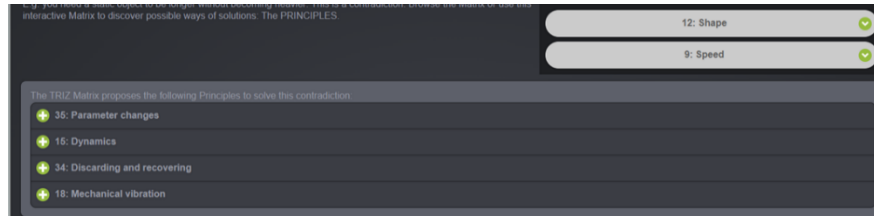


Figure 8: The TRIZ40 Solution to solve the contradictions that Ford faced. (TRIZ Matrix / 40 principles / TRIZ contradictions table, no date)

As seen above in Figure 8, the TRIZ matrix has provided 4 solutions to the contradiction that Ford faced, the solutions proposed by TRIZ40 are “Parameter changes, Dynamics, Mechanical vibration and discarding and recovering”, and these are what Ford used, as mentioned in section 2.3, Ford discarded the conventional MacPherson strut, and created a design for their suspension dynamics that would change the parameters of the car whilst also not only retaining the ability to dampen mechanical vibrations, but improving upon it.

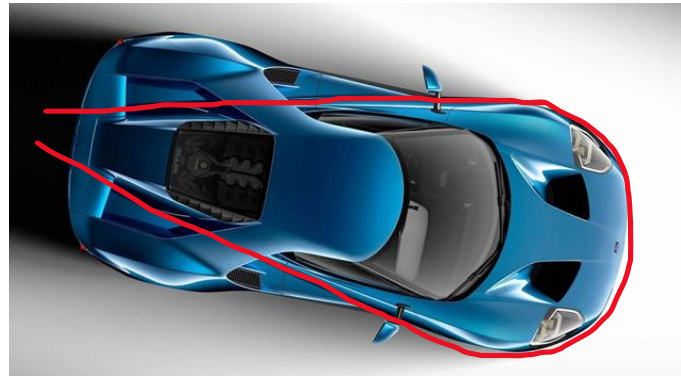


Figure 9: a top view of the 2017 Ford GT demonstrating its teardrop shape. (Best Ford GT 2017 Top View | Ford GT 2017 Top View #FordGT, ... | Flickr, no date)

As seen above in Figure 9, Ford implemented their teardrop shape, meaning now that all the air can flow over the body of the car and meet again at the back, massively minimizing the negative pressure at the back of the car, and therefore reducing drag to the benefit of straight-line speed, which is greatly beneficial when racing at LeMans.

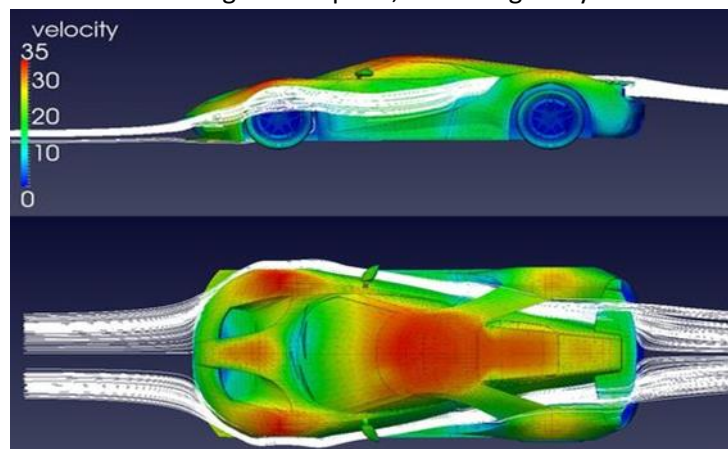


Figure 10: Image representing how the teardrop shape implemented into the Ford GT works, demonstrating the air meeting at the back and reducing drag. ((232) Pinterest, no date)

2.7. Data Analysis and Computational Engineering (CAE).

CAE and data analysis were extensively used during the development of the 2017 Ford GT, especially in the aerodynamic design. For example, look to Figure 10. As well as Figure 11 (below).

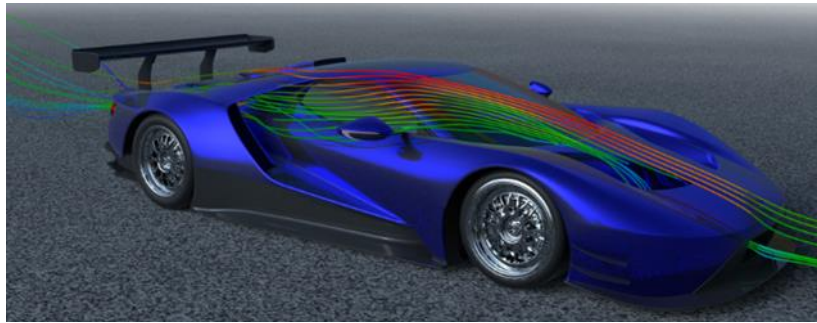


Figure 11: CAE Design of the Ford GT that was created in model scale wind tunnel and the Elements CFD software(ARC Proud To Have Supported Ford GT Development, no date).

Ford developed and tested their aerodynamic shape in a variety of CAE formats and techniques because it was a high priority to them considering the race that it would be entering. Multiple examples of data analysis can be found online demonstrating how the car performs, for example in Figure 12 (below), you can see the Ford GT's Horsepower and Torque curves.

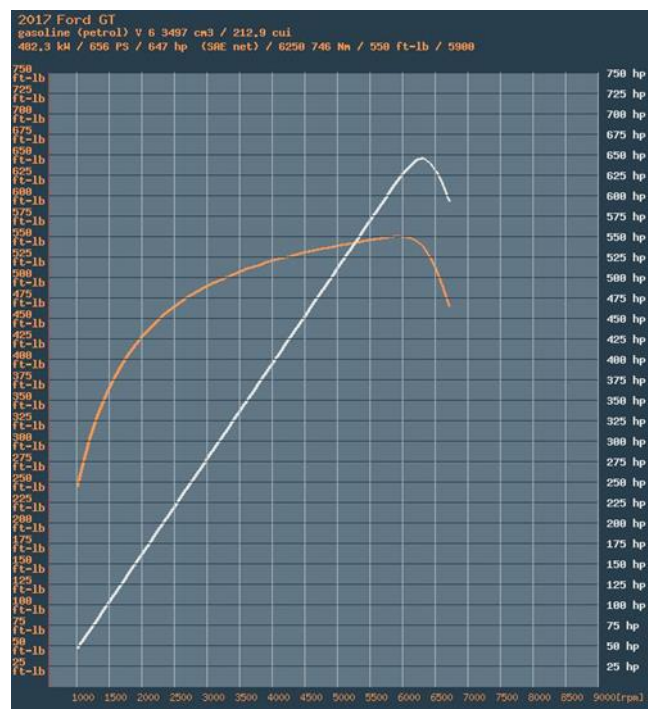


Figure 12: A horsepower and torque curve of the 2017 Ford GT.(Horsepower/Torque Curve 2017 Ford GT (d-cl. 7) (model since December 2016 for North America). Detailed engine characteristics., no date)

Other organisations have also measured and compiled a variety of data on the 2017 Ford GT, for example 'Road and Track' made an "official performance test report", which is shown on the next page in Figure 13, as well as a CAE created diagram displaying various electrical sensors and modules in the car, which is also displayed on the next page in Figure 14.

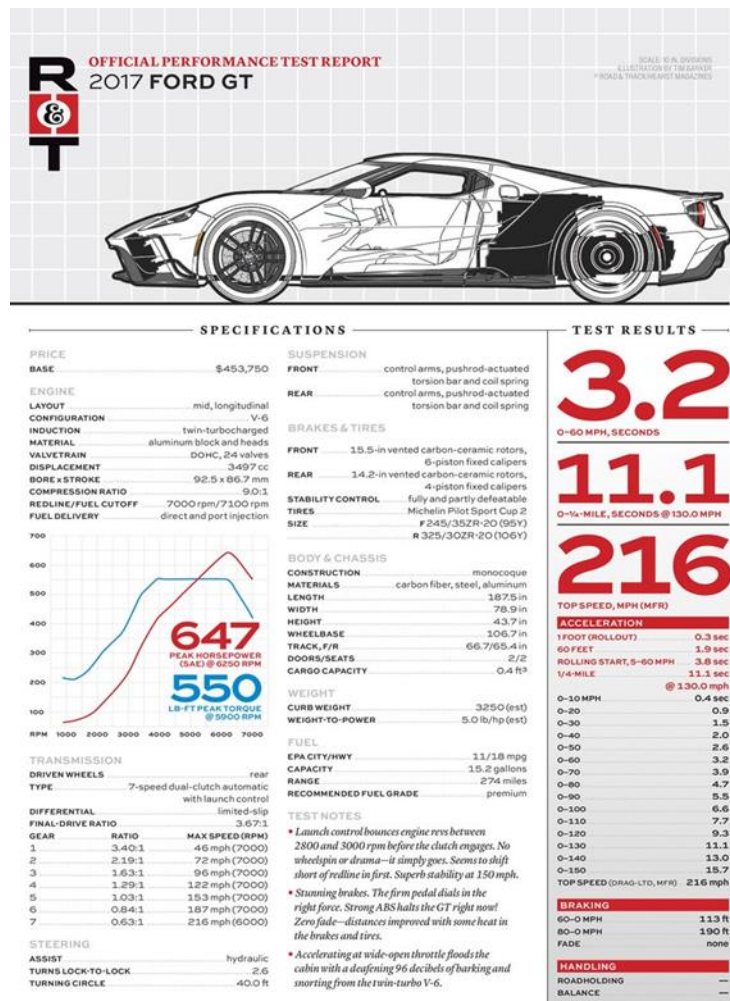


Figure 13: Road and Track official performance test report data sheet. (First Drive: 2017 Ford GT, no date)

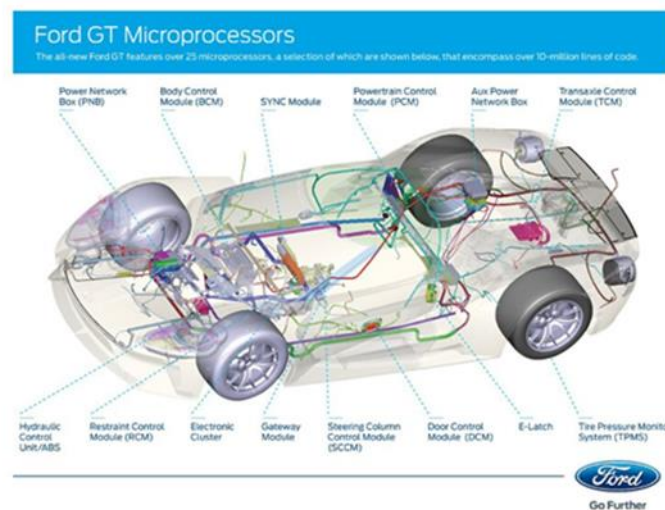


Figure 14: Ford GT Microprocessors CAE Diagram. (Maximizing 2017 Ford GT Function, Design & Active Aerodynamics with Wind Tunnel Testing, no date)

3. State of the industry.

The 2017 Ford GT Fits into the current car industry quite well as it is a relatively recently developed car, and therefore complies with most modern laws and regulations, to the degree that Ford still is currently developing the next car, the 2022 Ford GT MkII, which has also got a race variant, which is displayed below in Figure 15. Which has been improved in such a number of ways that it currently costs 1 million pounds, making it the first million-pound GT to hit the market.



Figure 15: 2022 Ford GT MkII. (This is the track-only, £1m Ford GT Mk II | Top Gear, no date)

Thanks to the car's modern features like electronic assists, performance enhancing features and its ecoboost engine, it not only fits in with modern carbon emissions regulations, being estimated by the US EPA (environmental protection agency), that it runs at 12mpg in cities and 18 on motorways, which is more efficient than other supercars it competes with. but it also still competes very well within the modern racing scene also, still competing at LeMans and consistently Performing very well in most races it enters, with 3 Ford GT's positioning in the leading third of the LM GTE PRO class in their most recent entry at LeMans.

4.Conclusion.

In conclusion this technical report will cover all the design and development of the 2017 Ford GT, outlining the effects of features spanning from the materials used to build it and the processes used, all the way to the aerodynamic design, suspension dynamics and the CAE used in development. Each of the topics covered discusses the effects and processes of how it affected the car or how it was made, leading up to a short segment discussing how the car fits into the current modern car industry.

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