



AMG
PETRONAS
FORMULA ONE TEAM

DESIGNING A RACE CAR

THE MERCEDES-AMG FORMULA 1 TEAM'S ENGINEERING & DESIGN PROCESS



By Shayaan Azeem, Zane Beeai, and Rohanth Mareem from Team 2106A.

WHY PICK MERCEDES AMG F1?

Established in 2010, the Mercedes-AMG F1 Team has a record of eight championships in Formula 1 competition. F1 stands as the largest motorsport competition and the pinnacle of automotive engineering. We chose Mercedes-AMG for their ingenuity and consistency; being a top team requires immense rigour and the ability to apply it consistently. This was our team's guiding principle for success.

Our Resources and Approaches to Understand the Mercedes-AMG Engineering Design Processes

Utilizing online resources, focusing on YouTube videos wherein experienced professionals on the team explained concepts of their Engineering Design Process. Another source of information was the GoF1 Show podcast featuring Andrew Shovlin, the Mercedes-AMG's Head of Engineering. Using these resources, we were able to gain insight into the approaches used by Mercedes AMG F1.



How Do F1 Teams Design, Produce and Race an Upgrade?

81K views • 7 months ago

Mercedes-AMG Petronas Formula One Team

Upgrading an F1 car is no easy task. It's a real team effort across many departments, over the course of many weeks to deliver.



Exclusive Interview with Mercedes' Andrew Shovlin - French GP Preview '22

8K views • 1 year ago

GoF1 Show

After eight consecutive World Constructors' Championships in the turbo-hybrid era, Mercedes-AMGF1 suddenly finds itself

Assessment of pace vs pole/win halfway through the season. | Why the car isn't as quick in real life... 7 chap

THE ENGINEERING PROCESS

The engineering process of the Mercedes-AMG F1 Racing Team is based on their seven key steps in developing a Formula 1 car (Figure 1). We've also showcased the engineering and design approach of our team, 2106A, in building robots for a VEX season (Figure 2). Our process outlines a step-by-step sequence throughout the season, drawing inspiration from the VEX design and engineering process.



FIGURE #1 : MERCEDES AMG FORMULA 1 TEAM ENGINEERING PROCESS



FIGURE #2 : #2106A WOSS ROBOTICS ENGINEERING PROCESS

#1 CONCEPTUAL DESIGN

The Mercedes AMG Formula 1 team begins the engineering process with ideation and architectural planning. Components and basic design fundamentals are considered and the car's fundamental base is established at this stage. It is also when Standard Supply Components, designed by the FIA (Formula 1 Governing Body) are installed.

CONCEPTUALIZATION

At 2106A, we kick off the season by crafting the base drivetrain and establishing the fundamental structure of the robot. Essential components and foundational design principles are explored at the project's inception. For example, this season, we began constructing a drivetrain, considering the new game's challenges, ensuring sufficient torque and speed to navigate the field.

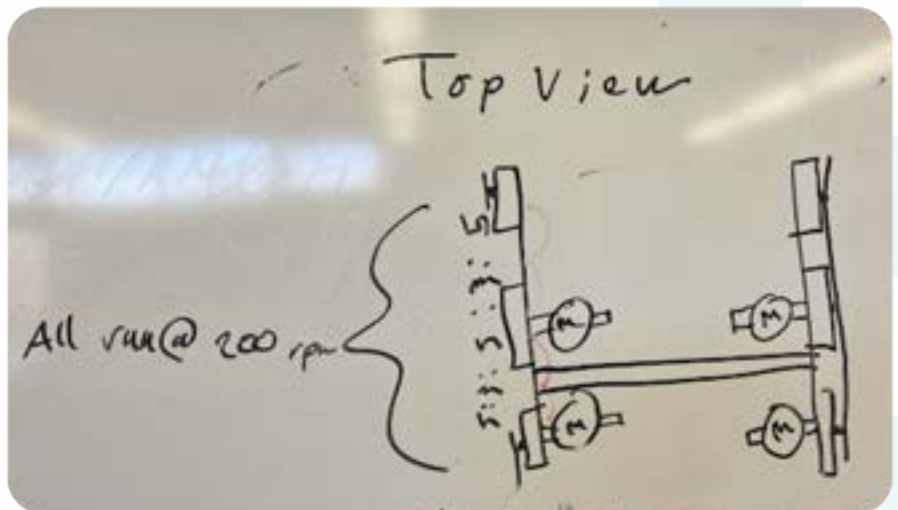


FIGURE #3 : CONSTRUCTED VERSION VS BRAINSTORM OF DRIVEBASE V1

#2 REGULATION ANALYSIS

Formula 1 teams, including Mercedes AMG, rigorously study yearly regulations after fundamental design and system installation to identify constraints for creating an eligible car.

GAME MANUAL ANALYSIS

Similarly, our VEX team recognizes the importance of comprehending the game manual and rules. Therefore we invest time in learning game rules, identifying design constraints, and exploring the game strategy.



FIGURE #5 : VEX OVER UNDER GAME MANUAL AND GAME FIELD

#3 DESIGN AND DEVELOPMENT

The Mercedes AMG team leverages CAD for iterative design enhancements, focusing on aerodynamic improvements based on Formula 1 regulations. CAD is crucial for creating multiple versions efficiently while still meeting regulations to gain a competitive advantage.



FIGURE #6 : MERCEDES AERO ENGINEER DESIGNING A REAR WING IN CAD SOFTWARE AND A CAD MODEL MERCEDES F1 CAR



DIGITAL MODELING AND DESIGN

We make use of CAD software to streamline our design process. We design robot iterations in compliance with game rules and strategy. This season, we designed various catapult versions in CAD to test functionality and feasibility, employing applied mathematics and physics.

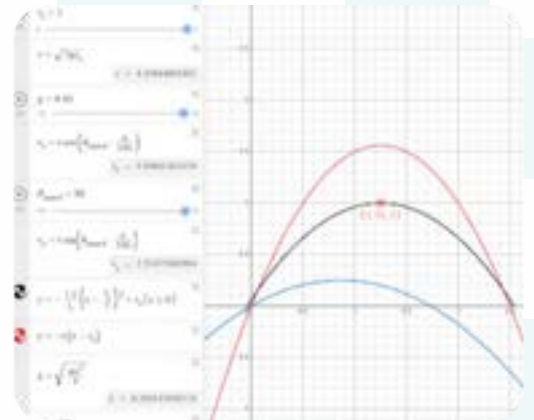


FIGURE #7 : CAD RENDERS OF CATAPULT V1 AND THE MODEL OF THE OPTIMAL ARC FOR ACCURACY AND SPEED

#4 TESTING AND VALIDATION

After creating a solid car design, the Mercedes AMG team conducts testing virtually and in the real world, using Computational Fluid Dynamics software for simulations on different models. Car subsystems are tested to ensure functionality.

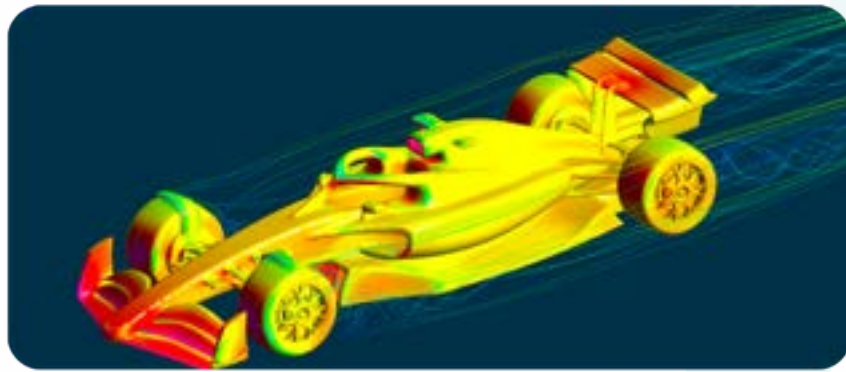


FIGURE #8: COMPUTATIONAL FLUID DYNAMIC AERO TEST OF F1 2021 CAR

SUBSYSTEM BUILD AND TESTING

In our process, this corresponds to the Subsystem Build and Testing stage. We construct feasible subsystems identified in the design and CAD stage. For example, the real-world model for our catapult is built and tested for functionality.



FIGURE #9: EARLY STAGE BUILD OF THE CATAPULT BASED OFF THE CAD MODEL TO TEST FUNCTIONALITY

#5 MANUFACTURING AND INTEGRATION

Following design and testing, the Mercedes AMG team manufactures components using composites and metals, adding powertrain, suspension, and aerodynamic elements to create a functional prototype. Subsystems are also integrated in this stage.



FIGURE #10: COMPLETELY ASSEMBLED PRESEASON PROTOTYPE VERSION OF MERCEDES W12

FINAL PROTOTYPING AND BUILD

In our VEX Robotics team, once all systems are functional, we move to the Final Prototyping and Build Stage. Here, the final robot is assembled, integrating the intake onto the drivetrain, along with the catapult and hanging mechanism.

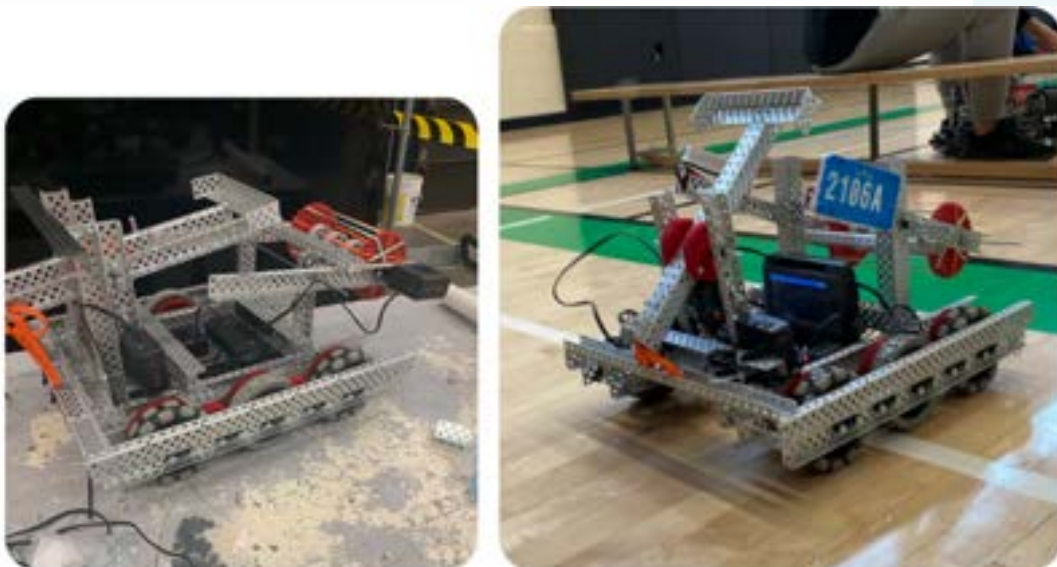


FIGURE #11: FINAL "THE WILDCAT" ROBOT FOR OVER UNDER WITH THE INCLUSION OF ALL SUBSYSTEMS

#6 FINAL TESTING AND OPTIMIZATION

After the final assembly, the Mercedes AMG team conducts inspections and tests components for FIA crash tests, leading to the first public car reveal and pre-season testing for performance validation.

FINAL TESTING AND FINE TUNING

Once our robot is constructed, we begin testing and gathering data, evaluating its performance on the game field. We make small adjustments to improve performance, balancing weight and placement.



FIGURE #12: MERCEDES W12 AT PRESEASON TESTING



FIGURE #13: "THE WILDCAT" ROBOT ON THE GAME FIELD FOR REAL WORLD PRACTICE

#7 CONTINUOUS IMPROVEMENT (THROUGHOUT THE SEASON)

The Mercedes AMG team continually evaluates race data and performance metrics, making incremental updates and improvements between races.



FIGURE #14: MIDSEASON MERCEDES W12 SIDE POD UPGRADES FOR FASTER STRAIGHT PERFORMANCE

Similarly, We revisit the design stage constantly, incorporating experience and data to enhance the robot's performance. For example, recognizing inefficiencies in our drivebase, motor placement, motor access and weight distribution, we went back and developed a new drivetrain.

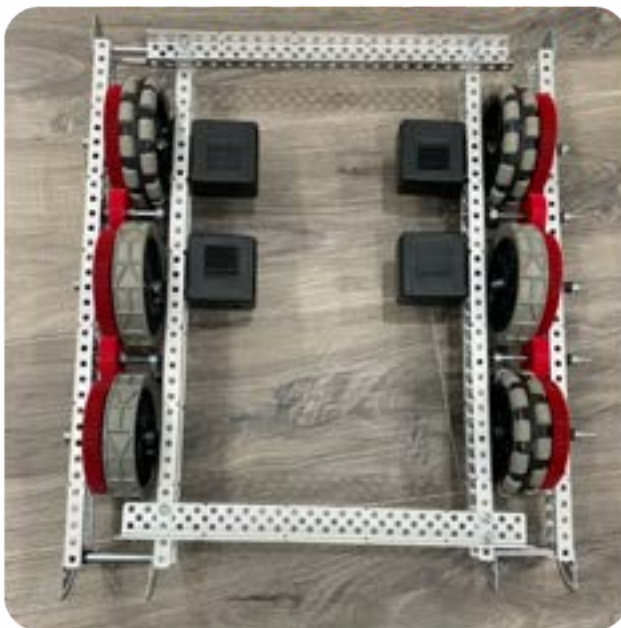


FIGURE #15: V1 VS V2 DRIVETRAIN COMPARISON, NEW SLOT FOR TRIBALL, QUICK SWITCH MOTORS, IMPROVED GEAR RATIOS

While Formula 1 lacks a programming stage after final testing, the software engineering aspect is present in both domains. In F1, teams constantly change car setups to ensure optimal performance on each track. This comes down to programming changes within the car's systems, similar to how we program our robot based on individualized competition situations.

HOW VEX PREPARES US FOR A CAREER AT MERCEDES-AMG F1?

Participating in a VRC team is a great pathway to a career at Mercedes AMG Formula 1 Team. VEX Robotics hones problem-solving skills and emphasizes effective work within constraints. Students gain a practical understanding of the engineering process, 3D modeling, and time management. Autonomous programming enhances logic and problem-solving abilities in a different context. Judged interviews and Notebooks refine communication skills crucial for an engineering career. In summary, VEX Robotics equips students with practical skills vital for success in dynamic fields like the world of F1 and Automotive Engineering.

WORK CITED

- GOF1 SHOW. (2022, JULY 19). EXCLUSIVE INTERVIEW WITH MERCEDES' ANDREW SHOVLIN - FRENCH GP PREVIEW '22 [VIDEO]. YOUTUBE.
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=4G-OAF84FAU](https://www.youtube.com/watch?v=4G-OAF84FAU)
- MERCEDES-AMG PETRONAS FORMULA ONE TEAM. (2021A, JULY 27). HOW DO TEAMS DEVELOP A FORMULA ONE CAR? [VIDEO]. YOUTUBE.
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=GBKBWCK6-JW](https://www.youtube.com/watch?v=GBKBWCK6-JW)
- MERCEDES-AMG PETRONAS FORMULA ONE TEAM. (2021B, NOVEMBER 25). HOW DO YOU SET-UP A FORMULA ONE CAR? [VIDEO]. YOUTUBE.
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=3RZORFMG9ES](https://www.youtube.com/watch?v=3RZORFMG9ES)
- MERCEDES-AMG PETRONAS FORMULA ONE TEAM. (2023A, APRIL 10). THE CUTTING EDGE OF F1 | THE MACHINE SHOP | HOW IT WORKS [VIDEO]. YOUTUBE.
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=TOCMSKJESRS](https://www.youtube.com/watch?v=TOCMSKJESRS)
- MERCEDES-AMG PETRONAS FORMULA ONE TEAM. (2023B, MAY 18). HOW DO F1 TEAMS DESIGN, PRODUCE AND RACE AN UPGRADE? [VIDEO]. YOUTUBE.
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=DKEX4MHUC7W](https://www.youtube.com/watch?v=DKEX4MHUC7W)