DATA ANALYSIS FOR FORMULA 1

BY ELETTRA PREOSTI

Guillaume Dezoteux is Head of Vehicle Performance of the Scuderia Alpha Tauri Formula One team. He received a bachelor's degree in mechanical and automotive engineering from ESTACA Ecole D'Ingenieurs in 1993 before beginning his career in Formula 3.

In this interview, we discuss how data analysis is used to design and develop Formula One cars as well as optimize car performance during race weekends.

Franz Tost is a former racing driver and current Team Principal of the Scuderia Alpha Tauri Formula One team. After competing in Formula Ford and Formula Three, he studied Sports Science and Management while working as team manager at the Walter Lechner Racing School.

BSJ: What early experiences influenced your interest in racing, and how did you begin your career in Formula 1 (F1) ?

FT: Back in the 1970s, F1 races were telecasted by the Austrian broadcaster ORF, so as a young Austrian kid, I was able to watch all of the races. In fact, at the time, I was a huge fan of Austrian racing driver Johen Rindt. Watching him was my first introduction to F1. From then on, I made it my goal to work in F1. Fortunately, I was able to accomplish this goal, as in 1997, while working as Ralf Schumacher's manager, I joined the F1 team Jordan Grand Prix. From then onwards, I have always worked in F1.

GD: I am from the French Basque Country in the area near Biarritz; it is an area which is famous for surfing and rugby—not really for motorsports. But, when I was younger, I was still a big motorsports fan, and I would go Go-Karting with one of my friends. I was also really interested in science and, specifically, mechanical engineering. That was where my drive came from. However, at the time, I did not know anyone in the motorsports industry or even anyone that was familiar with motorsports. So, I went to Paris to study mechanical engineering. Then, in my spare time, I went to driving schools and worked on vintage racing cars. After I received my engineering degree, I went on to work in Formula 3, where I had my first experience working on single seater cars, and eventually became a race engineer. This was a really useful experience for me as I was able to learn more about car set-up and aerodynamics. Then, in 2006, I had the opportunity to move to Scuderia Toro Rosso. This was my beginning in F1.

BSJ: Can you briefly describe your respective roles as Team Principal and Head of Vehicle Performance of a Formula 1 team and your responsibilities both during and outside of race weekends?

FT: As team principal, during race weekends, my main job is to oversee team operations. However, I must also do a lot of press work, which includes attending marketing events and meeting with partners and sponsors. Finally, before every race, I must attend meetings hosted by the Federation Internationale de l'Automobile (FIA), the governing body of motorsport, with all of the other team principals. Outside of race weekends, my main job is to organize meetings where we discuss prior race weekends and plan for the future. During these meetings, I seek to identify the team's deficiencies and how to improve upon them so that the team can become more successful. Then, of course, it is always important for the team principal to find sponsors, as sponsorships reflect our perceived performance. And, throughout the entire year (both during and outside of race weekends) my job is to keep the team motivated.

Figure 1: Alpha Tauri Car #10 at the 2021 Monaco Grand Prix.

GD: I manage a group of engineers whose main responsibility is to optimize the performance of the car. For example, we have a group of race and performance engineers who actively participate both in equipment testing and during races. We also have a group of tire engineers that analyze tire performance. Although all F1 teams use tires manufactured by a third-party company, Pirelli, we must still figure out how to optimize tire usage for our own cars as this is a key performance differentiator during races. Then, we have a group of strategists who have two main responsibilities: race strategy, which involves using simulations to make live decisions during a race; and competitor analysis, which involves comparing our strengths and weaknesses to those of our competitors. Another group is the vehicle dynamics group, which contains a number of experts who specialize in maintaining different parts of the car such as suspension, power unit, and brake system. Finally, we have a simulation and software tool group, which develops tools and methodologies in order to run simulations for the rest of the group. While we mostly work on a short time scale, we also participate in the long-term development of the car by analyzing its development through the season in order to determine what areas we need to improve and to define key parameters for the next year.

BSJ: What are the key ingredients in designing a Formula 1 car, and what is the overall design process like?

FT: The entire process begins with setting regulations for the upcoming season. Once these regulations are fixed, our team's Computational Fluid Dynamics (CFD) department runs initial tests to better understand the newer regulations and determine how to proceed with car design. After this, we begin tests in our facilities' wind tunnel, which we use to replicate the interaction between air and the car moving on the ground. At this point, about sixty percent of the car has already been designed. If there is a good correlation between the test results done by the CFD department and the results from the wind tunnel, we can finally design the remainder of the car parts and produce and assemble the car. Then, we go racing!

We also must continue this process throughout the season so that we can bring updates to our car from race to race.

BSJ: In general, during a race, what parameters do you seek to optimize to maximize race performance?

GD: Throughout any race weekend, we seek to strike a balance between a car configuration that works best for qualifying versus one that works best during the race, although we do generally focus on optimizing the car for the actual race. One major component of this involves using simulation tools, such as Monte Carlo simulation softwares, to assess the importance of starting position on the final race result. For example, if we start a race a few positions behind our competitor but with a slightly faster car, will we be able to finish ahead? Another two factors we must consider are our car's overtaking ability as well as our car's ability to defend against someone that is trying to overtake our car. For instance, on a track where it is very difficult to overtake, we cannot necessarily compromise our qualifying pace (which determines our starting position) for a better race set-up. So, we try to build some statistical analyses to develop our understanding of these kinds of trade-offs, but they are generally quite complicated and generate very heated discussions.

BSJ: What track conditions affect the performance of the car, and how do these track conditions affect the car?

GD: To begin, F1 cars are very sensitive to wind because they are heavily driven by aerodynamics, so windy conditions can make determining the best overall set up around the track very difficult. For example, during pre-season testing, it was very difficult for us to find the right balance of the car around all of the corners in the track: some corners had strong headwinds whereas others had strong tailwinds. The differences in the direction and strength of these winds can massively change the aerodynamics of the car and, as a result, how much downforce the cars are able to produce.

Another key factor is track temperature, which can influence how the tires perform in terms of thermal state and thermal behaviour. As opposed to road tires, F1 tires are extremely sensitive to temperature, and you have a very narrow window to extract their best performance.

BSJ: What data do you collect during free practice sessions to determine what car configurations to use both during qualifying [sessions] and during the race?

GD: We use a very complex data framework which processes a live telemetry stream from the cars and organizes the inputted data by lap. In this way, we can monitor trends over a series of laps. We work on different levels. First, we look in detail at what happens to the car during corners. There are two main components to this. The first is corner balance, which describes the shifting of the weight carried by each wheel on the car. The second is how the car balance evolves from braking to the apex to the exit of the corner. Then, we look at the car behavior over a series of laps. For instance, we look at how tire temperatures and tire pressures evolve as well as how wind affects the downforce and balance of the car.

We also try to look at the average operating condition of the car and how it compares to the overall season and our simulations. Obviously, the cars behave differently from track to track, but there are still similarities between tracks (e.g., similar corners or track conditions). Thus, we analyze whether the car is performing more or less where we expect it to or if our performance is an outlier.

Finally, while it is difficult to model race scenarios during free practice, we do try to simulate certain situations. For example, we will try to run our car as close as possible to the one in front, which generally has a negative effect on the car, in order to assess the effects of another car's tow on brake system and power unit temperature.

BSJ: How do you adapt to changes in track conditions during a race?

GD: One important aspect is to be able to prepare for changes in track condition from session to session. For example, the third free practice session generally occurs in the morning, when track conditions are usually colder, whereas qualifying occurs in the afternoon when track conditions are usually warmer. It is not enough to react to this temperature change during qualifying [sessions] so we use our telemetry data to predict how to change the configuration of the car so that the setup is actually a good one.

We also try to look at historical data to see if it can help us understand track conditions that we did not expect. Have we experienced these conditions before? Have we seen this type of corner before? If so, how were we able to correct car balance? What kind of adjustments to set-up did we make? We can also use simulation tools to analyze the effects of different adjustments. For example, we can use our simulation tools to predict variations in tire thermal state or the effect of wind on tire temperature.

> "The most important factor is that they must have a passion for F1. You must really live 365 days a year for F1 because it is a very hard and time-consuming job."

We sometimes encounter scenarios which are not aligned with our previous simulations or historical data. For example, there might be something wrong with the car in terms of bodywork, adjustment, or aerodynamics, or maybe the tire is wearing at a higher rate than expected. We then immediately try to understand which first order parameter is having such a large influence on the behavior of the car and hiding all of the sensitivities we had predicted. As you can imagine, this is very difficult to do since we do not have historical references or simulations to assess this kind of behavior.

BSJ: How do you evaluate tire performance throughout the race?

GD: Throughout the race, we have a lot of sensors to monitor the tires as well as models that predict tire performance given different scenarios. Generally, we try to monitor the thermal state of the tires as well as the tire's wear rate. Since we do not actually have a direct measurement of tire wear, we use models that try to predict what the tire wear is. Those models are accurate in certain conditions and on certain types of tarmacs, but they are not accurate in other conditions. For example, when we have wear mechanisms like graining, in which you have a lot of damage on the tire surface, or blistering, which occurs when the rubber forming the tire is too hot, our predictions do not work as well. However, when we have a more linear standard wear mechanism, we have good tools to predict when we will run out of tire life.

We also rely on simulations in which we try to estimate how much energy is lost by the tire as opposed to how much lap time is lost if we are driving slower in order to prevent tire degradation.

BSJ: How do you use data collected by other teams to make decisions during a race, and even to develop your own car?

GD: Looking at all of the teams' data is a key aspect of what we do in vehicle performance, especially in the strategy group. Obviously, data from the other teams is very limited; we have some GPS data, and we can watch the other cars' onboard cameras as well as listen to communications between race engineers and drivers. Based on all of this input, we try to build an understanding of what the strengths and weaknesses of our package are, and what the other teams' strengths and weaknesses are.

Analyzing teams' data is also a key aspect of the medium term development in F1. We do not need anyone to tell us that with more power, more grip, and more downforce, we will go faster. This is pretty clear to everyone. What this data helps us determine, for example, is in which types of corners is extra downforce beneficial. Then, when we develop the car, we are able to filter out options that we think are suboptimal. In this way, we can focus on really small differences in car performance, as we are competing in such a tight midfield (within 0.2 – 0.3% of laptime, we can have five to seven cars).

BSJ: You have mentioned that you often use Monte Carlo simulations. Can you explain what these simulations entail?

GD: Monte Carlo simulations are generally used for race strategy. Obviously, it is not possible to simulate all strategies. Some Monte Carlo simulations build statistics on a set of scenarios by running a distribution of those races. Through this process, we try to build an understanding of what scenario will statistically bring you a better result. The Monte Carlo simulations are continuously updated with live telemetry data from the car during races.

BSJ: What other types of simulations do you run?

GD: We run many other types of simulations: some help understand what is the best trade off between downforce and top speed while others help assess energy management strategy for the power unit. The latter, however, might not be useful for understanding car balance and tire behavior. Thus, we use other types of simulations to add more sophisticated tire models. We have transient simulations to help us represent dynamic maneuvers drivers may do, to name a few.

BSJ: Do you have an example of a time when you made a mistake analyzing data, and how were you able to fix it?

GD: One of my worst mistakes occurred in Austin in 2019. All of our simulation and prediction tools were telling us not to pit again, so I was determined in making a one-stop strategy work. At the end of the race, one of our two drivers could not make the tires last until the end of the race and our second driver finished at the back. It was not until after the race that I realized that we had made a mistake in our live predictions. We were not updating our Monte Carlo simulations with the right numbers. Moreover, during the race, we were only paying attention to teams that were successful in using a one stop strategy, convinced that we could make it as well, rather than looking at how many teams had decided to change strategy. I think what is important in this kind of situation is to be able to admit that you have made a mistake and bounce back with solutions to prevent such a mistake from happening again.

BSJ: How do you see F1 developing in the future?

FT: I see a great future for F1. To begin, we are moving towards using synthetic fuel, which is carbon net neutral. In addition, our engines utilize two engine recovery systems: the Motor Generator Unit-Heat, which recovers energy via heat, and the Motor Generator Unit-Kinetic, which recovers energy via kinetics. This is very important for sustainability and for the environment overall.

BSJ: What advice would you give to someone who is pursuing a career in F1?

FT: The most important factor is that they must have a passion for F1. You must really live 365 days a year for F1 because it is a very hard and time-consuming job.

GD: Just try. Try to get involved in some motorsport activities. Try to get into this environment, work hard, and learn. There is no magic.

This interview, which consists of one conversation, has been edited for brevity and clarity.

IMAGE REFERENCES

1. Banner: Welch, J. (2018, November 21). *Birds Eye View of Roadway Surrounded By Trees* [Photograph]. Pexels. https://www.pexels.com/photo/bird-s-eye-view-of-roadway-surrounded-by-trees-1624600/
2. Figure 1: Thompson, M. (2021, May 21). *Yuki Tsunoda of Japan driving the (22) Scuderia AlphaTauri AT02 Honda during the F1 Grand Prix of Monaco at Circuit de Monaco on May 23, 2021 in Monte-Carlo, Monaco* [Photograph]. Getty Images / Red Bull Content Pool. https://www.redbullcontentpool.com/scuderiaalphatauri/CP-P-675292