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# Racing the future of production

## A conversation with Simon Roberts, Operations Director of McLaren's Formula one Team

By Joe Mariani

PHOTOGRAPH BY MARK THOMPSON

McLaren driver Stoffel Vandoorne during final practice for the Formula One Grand Prix of Brazil on November 11, 2017.

# RACING the FUTURE OF PRODUCTION

**A CONVERSATION WITH SIMON ROBERTS, OPERATIONS DIRECTOR OF McLAREN'S FORMULA ONE TEAM**

*by Joe Mariani*

CARBON FIBER, TITANIUM, and rubber hurtle around a racetrack at nearly 200 miles per hour. Engines roar and fans cheer as drivers throw their cars into every corner. Formula One racing is not only among the most exciting sports on the planet, but also perhaps the most technologically advanced. Every car is a symphony of advanced materials and novel design. Yet the real excitement starts well before the crowds and champagne of race day, and far away from the track.

It all begins with the hundreds of designers, manufacturers, and support staff that make up the race teams, which in reality are mid-sized manufacturing companies. But these race teams are not merely typical manufacturers. In an effort to shave every ounce of weight from the car, every tenth of a second from lap times, Formula One teams use nearly every advanced manufacturing technique available, from additive manufacturing to the digital thread. These technologies, in turn, change how the race teams must operate as a company. In short, Formula One race teams are already experiencing today the technological and management shifts that mainline manufacturers will likely see in 5–10 years' time.

To get a glimpse into that potential future and the fast-paced world of Formula One racing, we sat down with Simon Roberts, the chief operating officer of McLaren Racing. The interview was conducted by Joe Mariani, a research manager with Deloitte's Center for Integrated Research.

## Pushing the boundaries of the possible

JOE MARIANI: At its core, McLaren Racing seems to be a car manufacturer. I am sure we all have a picture of how cars come together, likely black-and-white images of a Henry Ford assembly line. Can you give us a quick overview of the design and manufacturing cycle that you go through every year to pull these cars together?

SIMON ROBERTS: Compared to most automotive industries, we do to ourselves every year what most big automotive companies will do every three to five years. We start designing our cars in March with the longest lead activities, which is the gear box. As the year goes on, we end up with draft regulations around August, and that is when we start laying out the chassis for the car based on whatever our research has been doing and where we think the sport is going so that we can be competitive for the next year.

MARIANI: But March is also the beginning of the race season. So are you designing the next car even before the current car is finished racing?

ROBERTS: Yes, we have a two-week mandatory shutdown in August, and really from that point on, we start having to split our activities in two between

### A QUICK GUIDE TO FORMULA ONE

**>> HISTORY** Formula One is the highest class of single-seat auto racing sanctioned by the Fédération Internationale de l'Automobile (FIA). While Grand Prix racing began in 1906, the inaugural FIA Formula One World Championship was held in 1950.

**>> RULES** The "formula" in Formula One refers to the set of technical and sporting regulations all cars must meet, determining vehicle size, engine performance, and safety standards. Teams have leeway to innovate within these rules, and the effort to gain milliseconds has resulted in the creation of technologies that are now standard on passenger vehicles, including disc and anti-lock brakes, rear spoilers, semi-automatic gearboxes, advanced engine monitoring, all-wheel drive, and electronic stability control.

**>> RACES** The most recent season comprised 20 Grands Prix, starting in March 2017 in Australia and ending in Abu Dhabi in November.

**>> PERFORMANCE** Current Formula One cars feature:

- 1.6 liter V6 turbocharged engines, limited to 15,000 RPMs. While teams do not disclose horsepower data, the engines are believed to produce as much as 1,000 brake horsepower
- A minimum weight of 722 kilograms (1,592 pounds)
- Top speeds in excess of 330 kilometers per hour (205 miles per hour)
- Ability to go from 0 to 60 mph (0-100 kph) in less than 2 seconds—and stop again almost as quickly

The power and downforce of the cars mean drivers can experience lateral loads of as much as 6G (six times the force of gravity) while cornering—similar to fighter pilots.

**Simon Roberts**
McLaren Racing chief operating officer

keeping the current car running and competitive and starting to think about next year. So right now, in early October, we are probably 50/50 in the design office and engineering. Obviously we race until the end of November, and we start the ordering long lead time parts to fill inventory from November onwards.

From those two points on, then, it is basically a rush to get everything designed and released, hopefully, in time for Christmas. That is normally about 16,000 components that have to be designed and then manufactured for the new car. Then, at the end of January, we build the first car.

So it is a fairly short lead time. We will pre-book capacity both internally and externally, and that will all come together on an hour-by-hour basis just before we launch the car. It is quite normal for us to literally only have a finished car in the few hours before the launch event.

> "Once we have built the car and start testing it and racing it, we change the car about once every 10 minutes."

MARIANI: That is fascinating, especially the comparison to a main line car company that may slowly design and build many thousands of cars, where you must very rapidly build a small number of cars.

ROBERTS: Yes, we only ever build four chassis, and there are only ever two fully built cars that will race. The other thing is that we never really stop. Once we have built the car and start testing and racing it, we change the car about once every 10 minutes. Every 10 minutes we get a new CAD drawing out. That is a kind of relentless upgrade of everything. Normal carryover from year to year of about 3–10 percent is typical. But by the time we get to the end of the year, it is about 0 percent. The entire car is new. It is just a rapidly changing environment really, meaning we are only ever committing to small batches of things. A batch of four to six is a fairly typical manufacturing run, because by the time we have made six front wings, we have changed the design and are doing something else.

MARIANI: When you are making these parts and fitting them together on such astronomically tight timelines, how do you ensure that everything is up to quality standards?

ROBERTS: Every part we make or buy is loaded to a work order, so we have full traceability. All the material and all of the inspections are tracked against the individual part number in the work order. We can trace right back to the mill where we get the metal from, and we can see who loaded the blank onto the machine, when it was loaded, when the part came off, when it went to inspection, and heat treatments, certificates, or checks that were done on it right down to the finished product.

MARIANI: I suppose that lifing process—where you can determine the useful life span for each individual part—does not end when they are entered into the system, but continues with the data actually gathered as the race car is driving?

ROBERTS: Yes, we have got these tiny little RFID chips. On carbon parts, we laminate them in under the skin. They are so small you can't even see them. On metallic parts, where we can, we attach them with a glue/resin system. But they are so small we can fit them inside bolt heads. So once we have issued the parts, we scan them so that it takes out all the human error of typing the life codes of part numbers.

The odd thing is that we do not sell anything in general terms. Everything we make is for our own race cars. So we don't ever have a sales transaction. In fact, our two race cars are actually stock locations on the system. So if you sat and watched our stock system on a race weekend, you can actually see parts booking onto the car or off of the car as mechanics make changes at the track. That also auto-records mileage, the number of starts, the time that part has been on a car to make sure that no part exceeds its life span or design limits. It is a bit like aircraft from that point of view. We are lifing at the level an aircraft does.

MARIANI: Tracking the individual location and life span of each of 16,000 parts seems like an incredible amount of detailed data. How do you bring together all of those parts and all of that data into one small car and make it work at peak performance?

ROBERTS: Where to start? Even before we get to the race track, we are running simulations. We are running simulations now for Japan, for example. We have a pretty sophisticated Monte Carlo simulation which has all the data we can find for every driver and for every team, what has happened at that event in the past, everything you can imagine. We probably run 50,000 simulations just to get our heads in the game and figure out what we need to do. That is just for a pure race strategy point of view.

In terms of the car itself, we are also running very sophisticated [digital twin] models of the race car. We are testing all of the parameters we can think of for the car—all the latest upgrades, all the suspension variables—they're all dialed into the computer. We then use that data in a driver-in-the-loop simulator, which is the ultimate test for us. That is one of the reasons why we think when we turn up at a track on a Friday, we always look slightly better in the first practice session than everyone around us.

## Adapting advanced technologies to real-world needs

MARIANI: In manufacturing, it seems like we often have the idea that new technology will simply replace human workers. But even amidst so much advanced technology, many of your processes still have strong manual components. Have you noticed a shift in what you ask of your workers?

ROBERTS: So what we notice is—because we are rushing—our work instructions to our people are very high-level compared to what you would see in an automotive or aircraft industry production facility. What we only recently realized is that it's OK, and that we actually rely a huge amount on the profound knowledge in all of our employees. We used to take it for granted, and the big thing that has changed is that we no longer take it for granted. So if they find something difficult or if we have got something wrong or if things have not worked out as expected, we really need to take notice of that.

"We probably run 50,000 simulations just to get our heads in the game and figure out what we need to do."

MARIANI: So much of the success of the race team seems to be about balancing high technology with the very human needs of workers. Our recent research[1] is pointing towards the fact that the greatest productivity comes when humans and machines are working together to do what neither could do alone. How do you strike that balance or find the right mix of human-machine teaming?

ROBERTS: It varies. On the composite side, which is all the carbon fiber, chassis, body work, wings, etc., it is a fairly manual process. Our carbon molds are still handmade. We don't have any automated tape laying or laying of cloth. But we do use technology where we can. We use lasers on all the large components—chassis, front wings, rear wings, gear cases—to validate layout and dimensions. We can't afford to finish a chassis after eight weeks of laminating and discover that the third ply is the wrong material or laid in the wrong orientation. So we try and mistake-proof it using lasers and laser files.

The operation and monitoring of the car is another area where technology plays a significant role. In practice, we probably run up to 500 channels of data on the car during a practice session. All of that feeds back in real time to the pit wall, and then back to the factory in Woking, England where engineers try to piece together a picture of what the car is actually doing vs. what we want it to be doing at that particular track at that time.

However, once the race or qualifying starts, we are limited by regulation to only 250 sensors on the car. So we must use quite a lot of clever methods both on- and off-car to effectively combine channels and find more interesting data in virtual channels. As a result, the whole telemetry system on the car is set up so that it looks after itself. It will automatically flag channels where data is going out of limits or rising or falling faster or slower than expected. This demands a close cooperation between humans and the automation.

One example is gear shifts. When a driver calls for a gear shift, it actually puts two gears in mesh at once, because it is so fast that, as the torque loads up on the new gear, you can, with hydraulic pressure, pull the old gear out without smashing the teeth off it. But that gets a bit glitchy on wet

McLaren's Technology Centre in Woking, England

pavement when you get a lot of unexpected wheel spin, which the algorithm doesn't like very much. If something like that happens and a driver calls for a shift, it won't just bang two gears in without using the clutch, it will dip the clutch in, take one out and put one in. That is what we call a "safe shift." It takes a few milliseconds longer and the drivers don't like it. So that kind of thing is happening all the time in the background.

MARIANI: That concept of telemetry looking after itself and how it interfaces with the driver and the crew on the pit wall seems like a form of AI-human interaction that we have seen other industries, including aerospace and defense, struggle with. So that seems to be a very interesting solution.

ROBERTS: You know we are looking at AI and how we can use it, particularly, in the optimization of simulations and stuff. It is the same with big data.

> "We are trying make sure that everyone is very free with their data internally. Because you never know how what you're doing is going to affect someone else."

We have inadvertently been doing big data and a low-level version of AI and Internet of Things for a while really. But because we are not in that field, we put all of our time and energy into developing the racecar, we don't look at these things and badge them.

## Maintaining speed and flexibility

MARIANI: With all of the sensors on the car generating so much data, and some analysis being done on site, and some back in the United Kingdom, how do you divide up the workload between track-side and the facility back in the United Kingdom?

ROBERTS: In terms of division of tasks, in simple terms, what happens is, the stuff where you need cool, calm calculation and analysis, and detailed thinking is best done back here at the factory. An example of that in the race is trying to work out tire degradation for all our competitors or fuel usage by all competitors, so that we can strategically decide if we want to push hard or back off at a certain stage of the race. That is really hard to do if you are in the back of the garage with all the heat and emotion of the race, but relatively easy to do if you are sitting back at your desk in mission control here in a nice air-conditioned unit with headphones on. You only hear the things you need to hear, and you have loads of computers and power around you if you need it.

If things go wrong and someone knocks a bit off the side of your car, the guys at the track are only going to check if it is safe. They will look at the loads on the wishbone of the wing and decide if it is safe to run. They don't have time to look at all of the aero data to see how many points of downforce we may or may not have lost at a particular end of the car. But the guys here will do all that and then advise them.

MARIANI: Talking about all of these complex processes both on the race day and in the manufacture of the car, because all of these components are so interdependent, does that change how the work groups must function together? In other industries, we have seen the rise of cross-functional teams or rotations between work groups. Your thoughts along those lines?

ROBERTS: We are trying make sure that everyone is very free with their data internally. Because you never know how what you're doing is going to affect someone else. Luckily, because we go racing every one to two weeks in the season, the race events force us—and force people—to get together communally. Even if they are not in the same office, they are all on the same intercom systems. Everyone has a role and everyone understands what they are trying to do and what the overall objective is. That kind of cuts through what, in many other companies, could grow into an issue.

## Managing change in an uncertain future

MARIANI: We have talked a little bit about how the technologies are developing, and your last comment talks a bit about how the organization is developing, so what is next for McLaren? What is on the horizon? What is the next big technology or organizational shift that will take you even faster?

ROBERTS: If only we knew …

MARIANI: That's right, you will know it when you find it!

ROBERTS: I think the future is really about giving people the balance—the balance of technology, balance in their lives. I have noticed that the engineering organization here is quite resistant to organizational change, more so than other groups here. I don't actually know, but my hunch is that, because their world changes—either the regulations every year or the designs they are working on, the parts they are making—the one thing they cling onto for a bit of stability is where they sit in the organization. We ask so much of them, and they give so much, we are OK with giving them a bit of stability. It doesn't stop us from doing what we need to do as a team.

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1. Joe Mariani, Brenna Sniderman, and Cary Harr, "More real than reality: Transforming work through augmented reality," *Deloitte Review* 21, July 31, 2017.