5G Use Case

SAMSUNG
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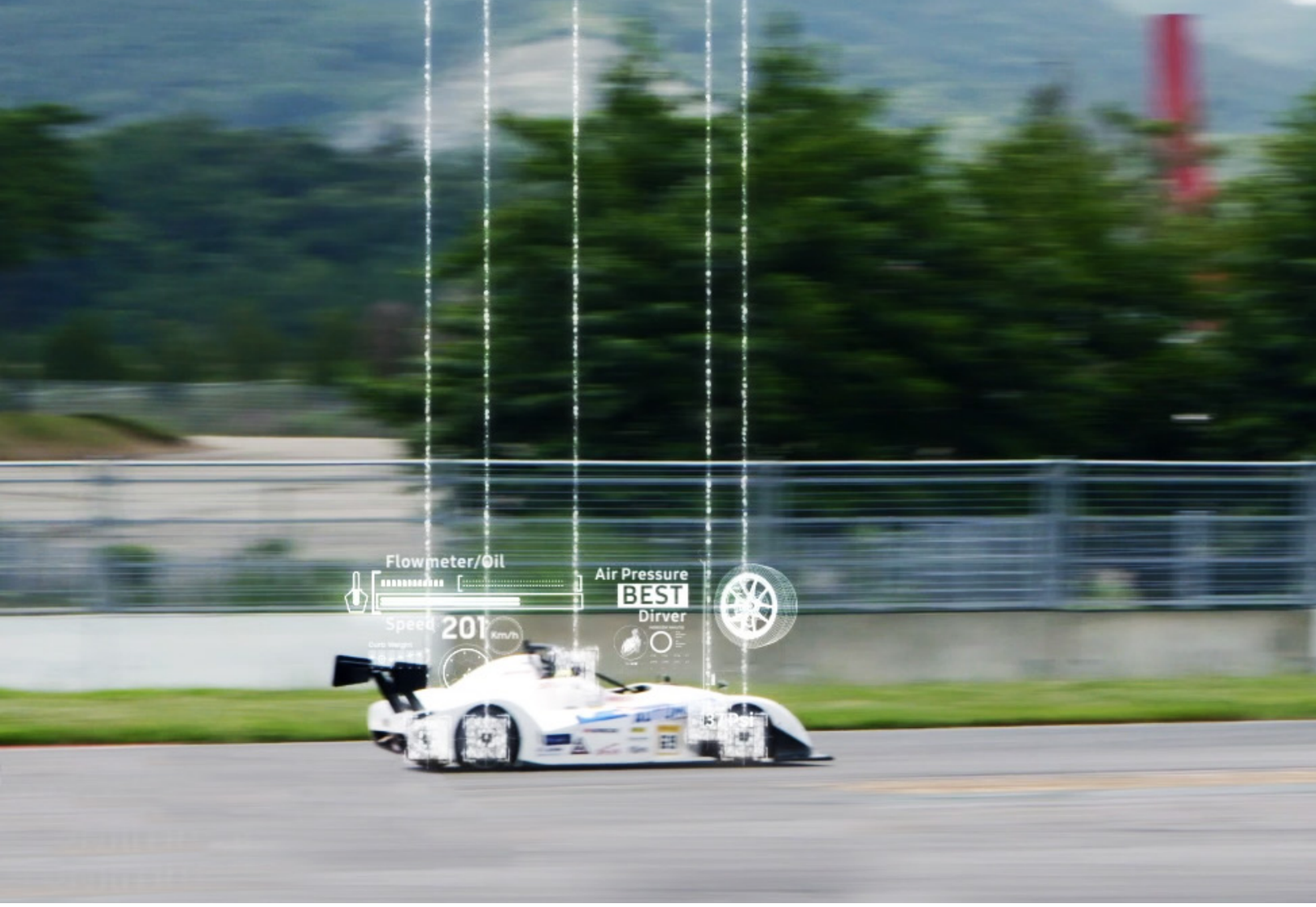
5G Transform Car Racing

Improve performance, enhance watching experience, save lives in car racing



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Introduction

Formula One, or F1, is the highest level of racing competition in the world today. There are more than 600 million fans worldwide who tune in to watch the races each year. The sport showcases an array of thrills through the speed, strength and agility of its drivers and the skill and technical excellence of its racecar constructors. In a constant pursuit of faster and more efficient lap times, F1 engineers constantly pursue advancements in engine power, manufacturing precision and the sensitivity of the various electronics and sensors that provide fine-grain details about everything from engine timing to aerodynamics. There truly may be no other sport better suited to demonstrating the value of technological innovation – driven by vast amounts of data to be collected, transmitted and analyzed.

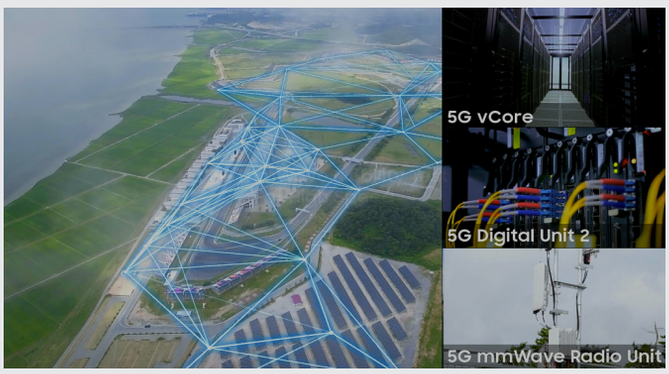
An argument can be put forth that in the world of cutting-edge motorsport, the speed of data is just as important to winning a World Championship as the speed of the racecar itself. Since 1980, race engineers have built team strategies around the analysis of collected data. Such data can be used to improve every aspect of the car as well as the performance of the driver. In an ideal world, this data is collected and analyzed in real-time, yet existing infrastructure limitations present a considerable challenge to realizing this scenario. Not for long. With 5G networks, ultra-fast speeds, massive connectivity, and near-zero latency promise to transform the involvement of engineers in live races.

> [1)]Formula One has always been on the cutting edge of technological development, so it was natural that data analysis would become a big thing for us. It saves us time and money–instead of having to rely on trial and error, we have real data provided by 2,000 sensors on the car.
>
> - Thomas Mayer, Former COO of the Lotus F1 team

1) Big Data In Fast Cars -- How F1 And NASCAR Compete On Analytics https://www.forbes.com/sites/bernardmarr/#379048cf30c8

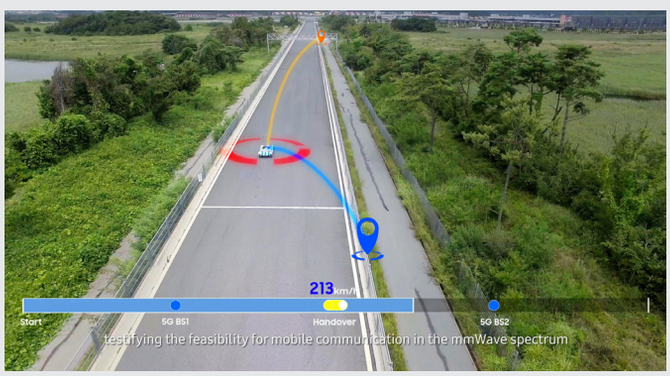
5G mmWave Mobility Test at High Speed

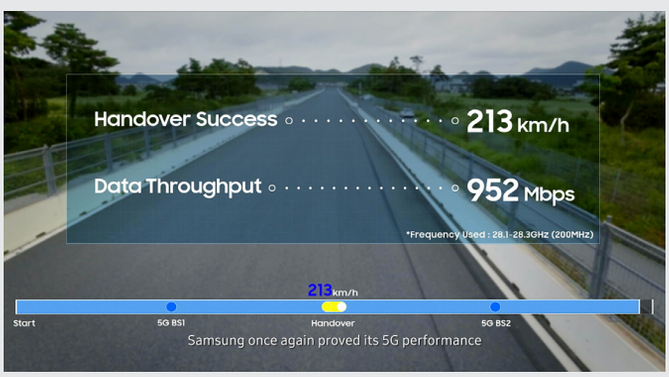
Samsung conducted handover testing at a racing circuit located in Yeongam City, near the south-west coast of South Korea. With 5G base stations installed around the track the goal was to understand how high-throughput data and radio transmission behaves in a high speed environment. Using 28GHz spectrum and a Samsung Galaxy S10 located inside a race car moving at speeds of up to 213km/h, Samsung successfully verified the stability and reliability of 5G connectivity even under fairly extreme high-mobility circumstances.



The 5G test network configuration included a 5G Core, 5G Digital Unit, 5G mmWave Radio Unit as well as the aforementioned Galaxy S10 5G. Engineers affixed the Galaxy S10 within the vehicle to test handover between two cells at racing speeds. The 5G base station and Galaxy S10 5G utilized in this test are already commercially available.

As the car accelerated through the handover zone, the handover status and performance data, as well as transmission characteristics of an ongoing data stream, were recorded for analysis.





According to the test results, the handover between 5G NR base stations was successfully achieved, at a vehicle velocity of 213km/h.

Peak downlink throughput was measured at 952Mbps, at a vehicle speed of 202 km/h.

The test results demonstrated that Samsung's 5G network solution can ensure reliable and effective data transmission even under ultra-fast speed conditions. In a motorsport environment, this allows for effective communication between the control tower, managing team and the vehicle; advancing the envelope of performance for both vehicles and drivers with the potential to deliver even greater, thrilling experiences for loyal fans while simultaneously providing for safer and smarter race tracks.

Real-time Monitoring on Cars and Drivers

Car Status Monitoring

Data plays a very important role in virtually every aspect of modern motorsport. Before a race even starts, an incredible amount of data, from chassis design specifications and engine output simulations to aerodynamics and tire pressures and temperatures, need to be collected and verified for safety and security; during the race, data is analyzed and used by each team's director to inform racing strategy decisions; after the race, data is collected and used to debrief drivers and engineers in preparation for the next race, where the cycle begins anew. Data is so important to the world of modern car racing, that it is just as valuable to a team's performance as the skill of the driver themselves.

To highlight this importance: each Formula One car is equipped with thousands of sensors that deliver millions of data points in a given race season. These sensors gather information on tire pressure, fuel burn efficiency, acceleration and braking patterns through corners and so much more – all of which need to be collected and transmitted for analysis and real-time troubleshooting. Some F1 teams even host their own servers for data storage and analysis. [2)]At a single race in 2014 alone (the U.S. Grand Prix), race teams collected over 243 TB of data, all of which was transmitted off-site for sanitization, formatting and analysis, so that teams could make appropriate changes to strategies and vehicles on-site.

But how to transfer this data is an ever-growing issue. Traditionally, engineers used a wireline connection to collect data, which was then deliberately sent to each relevant department – a time-consuming and inconvenient process. With track site 5G deployment, all of this data can be transferred in a secure, stable and ultra-fast manner directly to the data center where it can be automatically formatted and distributed to relevant engineering teams and strategy decision-makers.

Real-time monitoring with 5G networks

> [3)]We measure whatever we need to manage during the race, and then we model to get the predictive intelligence on how the cars are going to perform.
>
> - Geoff McGrath, CIO of McLaren Applied Technologies

2) Ormula one wins riding on big data analysis http://dataconomy.com/2014/11/formula-one-wins-riding-on-big-data-analysis/

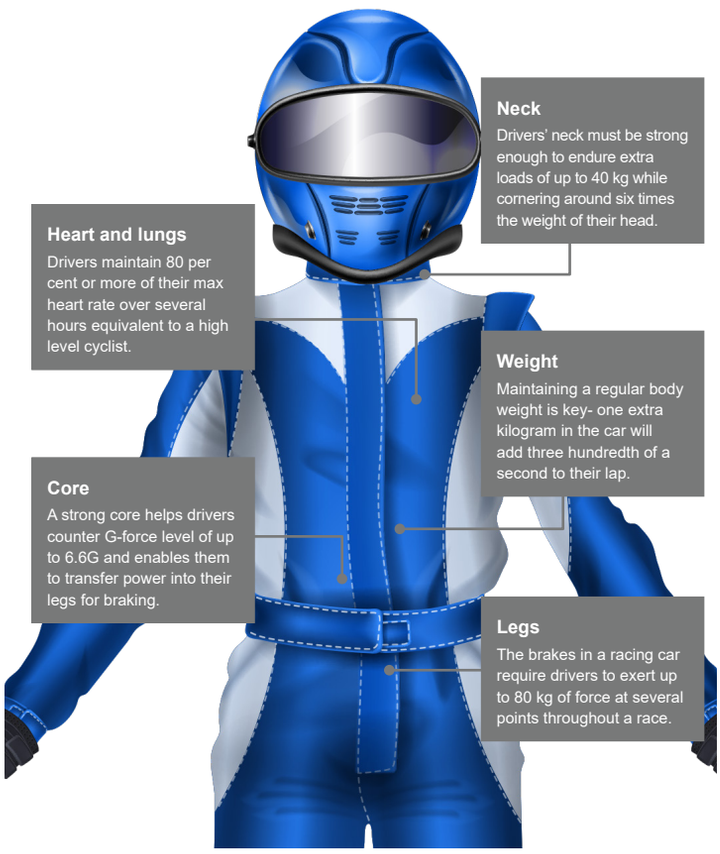
3) How Formula 1 Teams Use Big Data to Win https://fortune.com/2015/11/12/big-data-formula-1-championship-race/

Driver Status Monitoring

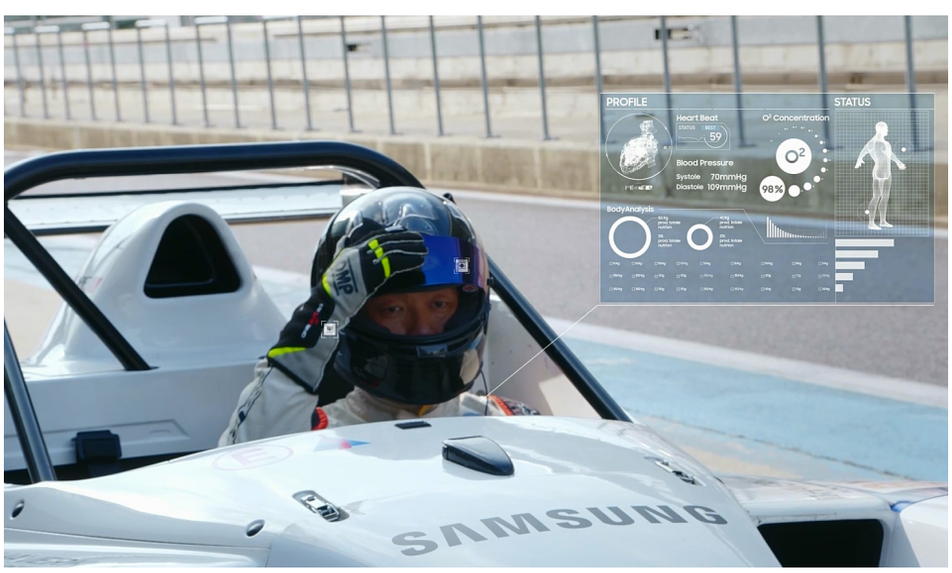
According to statistics motorsport health professionals, the sport is physically demanding on the drivers' health. [4]Because of the high-speed, high-mobility nature of Formula One racing, a driver's general health condition should be closely monitored during and throughout each race, which can last up to two hours (specifically limited for driver safety) and involve dozens of laps coving over 300km driven.

A few examples can help us to better understand the importance of actively monitoring driver health status. [5]Dehydration, for example, highlights a key challenge for driver health. During a race, temperatures in the cockpit may reach 50-60℃ and drivers can easily lose 4kg of weight to fat consumption and sweat. An unaccustomed or non-professional driver might experience shock due to dehydration of this nature. And while professional F1 drivers can still walk from their vehicle and celebrate victory, the race time risk of dehydration is real and needs to be managed.

Another good example involves the neck protection of racing helmets. Professional F1 drivers tend to have unusually strong neck muscles developed due to the g-forces sustained during high-speed turns. [6]During such turns, a driver's head can easily experience 5 g of centripetal force. Monitoring g-force data and body reaction under such circumstances will help doctor to better understand a driver's health condition.



Before 5G, this physical data would be collected manually by a doctor after each race. The existing wireless monitoring solution as LTE or Wi-Fi has their limitation. LTE bandwidth is limited and Wi-Fi coverage sometimes is not secure enough. With a 5G network in place and the implementation of advanced wearable devices, health-related data can be collected in real-time during the race. If an accident were to happen, the embedded sensors and the reliable 5G connectivity would provide medical staff a more immediate understanding of what happened and what is treatment is needed.



4) Drivers As Athletes https://www.indycar.com/Fan-Info/INDYCAR-101/The-Drivers/Driver-Fitness

5) Inside Mercedes' F1 factory: Simulator, data and sensors https://www.idgconnect.com/idgconnect/opinion/1009167/inside-mercedes-f1-factory-simulator-sensors

6) Formula 1: Are F1 Drivers considered Athletes? https://bleacherreport.com/articles/30864-formula-1-are-f1-drivers-considered-athletes

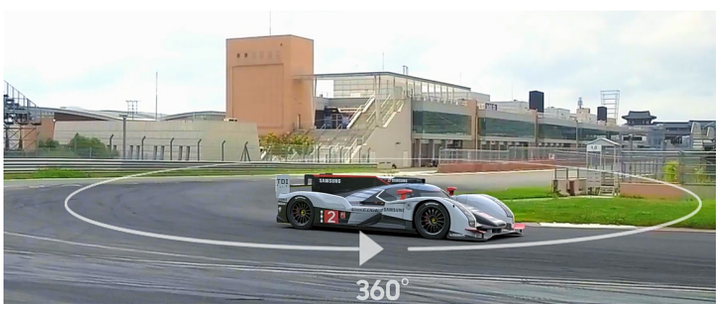
Transform Car Racing Watching Experience

For the loyal fans of motorsport, 5G has the potential to change the way races are experienced. However, traditional television format with a couple of play-by-play voice presenters and the race coverage is curated for you - they choose the camera angles and decide when to show which driver and which statistics. It's very static. If you have a favorite driver or team, they may only be on screen for 5% of the whole race if they aren't in leading place. 5G enables Formula One to put curation into the hands of the viewers - they can choose the cameras, the angles, the drivers they want to follow, etc.

Sitting at home, 5G will enable simultaneous and selectable viewing of the thrilling trackside atmosphere or from the driver's perspective in full UHD. For fans at the racing site, handset applications could leverage Augmented Reality (AR) and image recognition to provide up-to-date driver and vehicle statistics, simply by focusing the phone's camera at a given car.

First person view, 360 degree view, on air view – fans can choose any point of view according to their preference and despite the vast number of camera views available, the capacity of 5G ensures no compromises on image quality.

Instant race replay with time slicing function is made possible with 5G due to the capacity and throughput performance of high frequency millimeter waves. With ultra-clear images taken by cameras throughout the stadium, viewers can watch and replay each thrilling moment.



By cooperating with other content providers, 5G networks can bring race fans a vivid watching experience with 4K quality video provided by camera and drones. Motorsport fans can deepen the immersion from the comfort of their home through Virtual Reality headset.

Combined athlete data within racing app, 5G can help fans to have a real time database access for both vehicle and athlete. Furthermore, AR can be leveraged to provide guidance function for fans to track facilities such as restaurants or washrooms.

Wire-Free Broadcasting System for Broadcasters

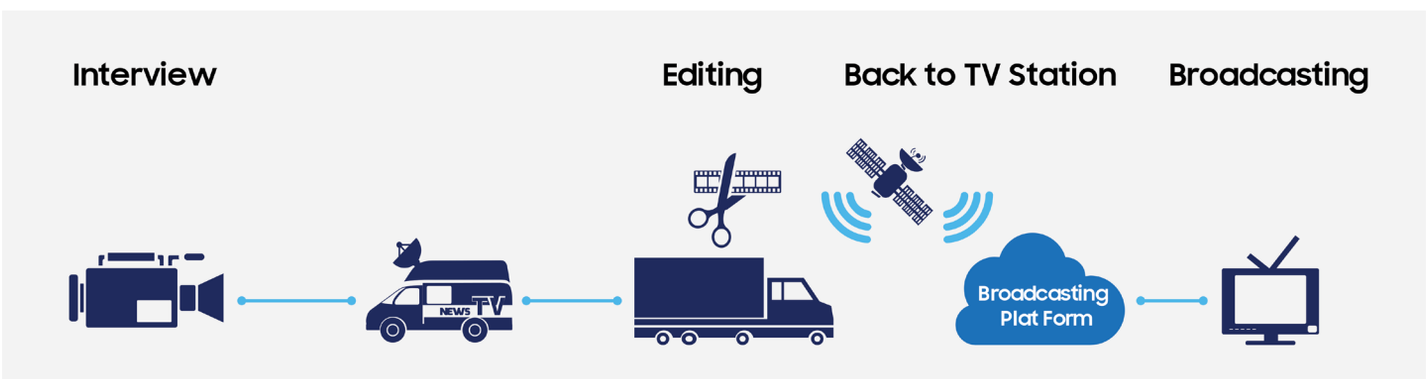
Motorsport fans always want a first-hand, real-time, vivid and immersive experience of the fast and furious moments, regardless of where in the world they may be on race day. How can the feeling and thrill of the race be accurately captured and transmitted to the audience? How can we bring the energetic atmosphere to each individual? How can we ensure the broadcasting experience more closely resembles a track side seat?

Unlike other sports game, in car racing sports, the camera installed inside vehicle must be wireless, so there isn't even an option for wireline. However, today's wireless broadcast technologies couldn't support the capacity required for 4K or 360 VR cameras on each car in a race.

Current standards for UHD resolution and surround sound can captivate a theater audience and are becoming increasingly common in home entertainment systems. Yet these place considerable demand on network transmission infrastructure as 4K becomes the norm, with VR and 8K on the fast-approaching horizon. A typical LTE connection may be able to handle one or two 4K broadcast streams. A 5G radio network could handle 20-30 streams or more depending on spectrum availability and video bitrates.

Today, TV stations typically rely on a mix of costly wireline transport networks and even more costly satellite transmission to provide end-to-end content delivery. As illustrated in the diagram below, several points of bottleneck or failure exist which serve as hurdles for programming directors and network technicians to constantly plan around. For example, each leg of the trip may require different encoding standards, increasing transmission delay and potential for error. Another key issue relates to logistics: once a wireline video connection is deployed, it serves as a static boundary limit for where cameras can and cannot be located. For production directors, they were bothered by the hard disk storage limitation- as 4k video carries huge amount of data, they have to replace the storage hard disk when it full.

Traditional TV Broadcasting Configuration



5G Network TV Broadcasting Configuration

> [7)]The 5G initiative could be a vehicle towards a co-operative use of broadcast and broadband infrastructures
>
> - EBU European Broadcasting Union

5G offers a solution to each of these issues. A wireless, 5G-connected camera allows cameras to be deployed virtually anywhere, providing dynamic shots from different angles and even allowing for fully simultaneous streaming from each, allowing the audience to decide which to follow. For production directors, content can be sent to the cloud in real-time for instant editing to support faster creation of comprehensive replay footage, for example. The same 5G network can then transmit the content to the viewers.

UHD resolutions and near-zero latency can bring even the most remote audiences to the race track. With AR and VR technologies, one could cheer alongside the crowd while sitting in his or her own living room. Through 5G networks wideband you would thus be able to share your UHD video and excitements with friends and family anytime any where even in the stadium which full of the crowd.

Compared with traditional broadcasting methods, 5G network supported TV broadcasting delivers several notable advantages as highlighted in the following table.

	Traditional Broadcasting	5G Network Supported TV Broadcasting
Flexibility	Poor flexibility, wired connectivity, broadcast van needed	Good flexibility
Coverage	Limited coverage footprint	Wider coverage
Stability	Satellite and microwave connection: unstable	More stable
Cost	Satellite fee, bandwidth rent fee: expensive	Abundant high-frequency spectrum availability, comparatively low cost

Compared with traditional broadcasting systems, 5G network supported TV broadcasting systems are cheaper, more flexible, more stable, easier to carry and cost effective. The gap between existing technologies and the delivery capability of 5G is considerable enough that 5G has the potential to drastically transform the way in which motorsport content is produced, distributed and consumed.

7) What 5G could mean for broadcast https://www.ibc.org/tech-advances/what-5g-could-mean-for-broadcast/2141.article

Safer and Smarter Circuits

When accident happens, every second counts in the life saving process. Immediate response and information sharing enable doctors to take the short cut to operation room. Saving life and minimizing injury are so essential in all sports games that there will be ambulance in every sports game. For racing car, there is even safety car to lead the racing when there is critical issue happened.

5G network improves efficiency of all those safety issues. Based on its extraordinary performance on reliability, speed and latency of communication, 5G brings revolution in the urgent care sector, providing instantaneously, comprehensive, reliable treatment with the help of wearable health device monitoring.

With 5G network, drone can increase the speed and effectiveness of rescue mission when there is an emergency. With 5G's ultra reliability and the help of wearable devices and the UHD camera, drone can help doctors to " see through'' the car when accident happened and provide them the real time athletes biological data for diagnoses. Also, by using 5G connected drone, first aid kits can be delivered as soon as possible for the wounded.

When the emergency happened, 5G network can immediately connect every part in need, from saving athlete on the racing site, to remote diagnose on the ambulance car, to vacant the road to hospital, 5G network functions as key element in the whole rescue process.

Conclusion

5G is more than just a network which transfer faster speed data, but rather a magic power to change every aspect of car racing. For vehicles and athletes, it can improve their performance; for sports fans, 5G will bring immersive watching experience; for the stadium management, 5G will make it safer and more efficient. For a broader sense, data effective transmission under high speed environment can also improve user experience for the high way and high speed railway passengers as it can offer immersive entertainment experiences.

With big data and powerful network, car racing sports combines those cutting edge technologies with human's instinctive reaction to satisfy human desire for faster speed. 5G technology provides a stable, powerful and secured network for data transmission. It will not only change car racing game, but also bring a new immersive entertainment experience for audience. 5G, will always be a power to push the game to a better stage.

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