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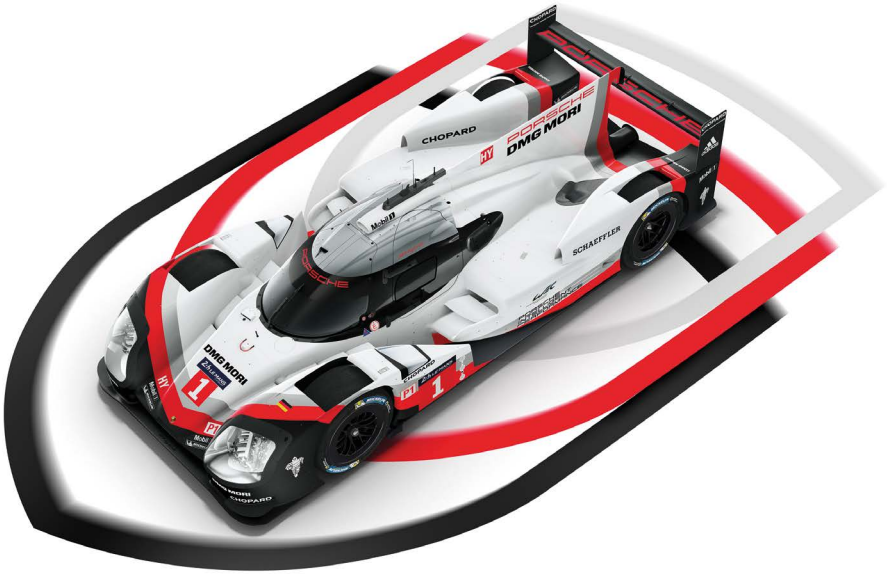

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March 2017

Contents

At a glance

Porsche sets its sights on a hat-trick

The Le Mans Prototype Porsche 919 Hybrid has been completely reworked and a new driver line-up is ready to go. In 2017 Porsche will start the new racing season with its sights set on winning the 24 Hours of Le Mans and the FIA Endurance World Championship for the third time in a row.

The over 900 hp (662 kW) hybrid racing car with starting number 1 will be driven by Neel Jani (33, Switzerland), André Lotterer (35, Germany) and Nick Tandy (32, Great Britain). Jani is currently joint WEC World Champion and 2016 Le Mans winner. Lotterer claimed the title of WEC World Champion in 2012 behind the wheel of an Audi and brings with him the experience gained from three overall victories at Le Mans, while Tandy formed part of the winning 2015 Porsche team at Le Mans. The sister car with starting number 2 will be shared between 2015 World Champion Timo Bernhard (36, Germany) and the two New Zealanders Earl Bamber (26) and Brendon Hartley (27). Bamber claimed joint victory with Tandy at Le Mans in 2015, while the same year saw Hartley share the title of World Endurance Champion with Bernhard.

“We want the hat-trick”, declares Fritz Enzinger, Vice President LMP1, setting out the ultimate goal of the 260-strong team in Weissach. In both 2015 and 2016, Porsche swept the board, winning the team’s 17th and 18th overall victory in Le Mans and securing the title of both Manufacturers’ and Drivers’ World Champion.

Enzinger continues: “Each and every one of the nine endurance races presents a challenge. Reliability is the basic requirement; six hours of navigating around the many cars in the different categories, each driving at different speeds, makes each race unpredictable – and ultimately it is often only seconds that separate the winner from the rest of the field. At four times the duration of the other races, Le Mans forms the pinnacle of the series. This 24-hour race pushes both men and machine to their absolute limits. Toyota is set to be a very strong contender in the top-tier LMP1 category for the 2017 season. We will face up to them with a meticulously enhanced Porsche 919 Hybrid and a team of six first-class drivers.” Team Principal Andreas Seidl will continue to serve as acting technical director.

WEC – the ideal platform for technological pioneers

With its unique efficiency regulations for Class 1 Le Mans prototypes (LMP1), the WEC represents an ideal platform for Porsche – and it was these regulations that fuelled the company's return to elite motorsport in 2014. The regulations provide engineers with an unusual degree of freedom to introduce different drive concepts and require forward-looking technologies such as hybridisation, highly efficient engine downsizing and consistent use of lightweight construction. As a result, the WEC provides the perfect platform for Porsche to develop and test innovations for road-going sportscars.

The Porsche 919 Hybrid's innovative drive concept

The hybrid drive on the 919 combines downsizing turbo technology with efficient direct fuel injection for the two-litre V4 combustion engine and uses a lithium-ion battery to store electrical energy from two different energy recovery systems (brake energy from the front axle and exhaust energy). The 919 Hybrid is the only prototype to recover energy during acceleration as well as braking. It boasts a system output of more than 900 hp (662 kW) and Porsche has already channelled a number of the Hybrid's features into the development of its road-going sportscars. The most obvious example of this is the 800 volt technology for the purely electric concept study Mission E, which, among other things, enables extremely short battery charging times. This four-door sportscar study is set to enter series production before the end of the decade.

Calendar

FIA World Endurance Championship (WEC)

The FIA World Endurance Championship (WEC) includes nine rounds, with the 24 Hours of Le Mans as the season highlight.

March 31	Unveiling of the Porsche 919 Hybrid in Monza (IT)
April 1–2	Monza Prologue (IT)
April 16	6 Hours of Silverstone (GB)
May 6	6 Hours of Spa-Francorchamps (BE)
June 4	Le Mans Test Day (FR)
June 17–18	24 Hours of Le Mans (FR)
July 16	6 Hours of Nürburgring (DE)
September 3	6 Hours of Mexico City (MX)
September 16	6 Hours of Circuit of the Americas (Texas, USA)
October 15	6 Hours of Fuji (JP)
November 5	6 Hours of Shanghai (CN)
November 18	6 Hours of Bahrain (BH)

Race series

How the WEC works

- The FIA World Endurance Championship (WEC) is the second highest ranked in world championship car racing, placing second only to Formula 1.

- The WEC features various classes of cars competing in joint endurance races. The classes are: LMP1-H (for hybrids), LMP1, LMP2, LMGTE Pro and LMGTE Am (the Pro and Am categories are for professional and amateur teams in the GT class).

- Generally: Vehicles in the LMP classes are prototypes that are not based on series-production vehicles. The designs of these vehicles are based solely on the technical regulations. In normal circumstances, only LMP1 vehicles (class 1 Le Mans prototypes) have a chance of overall victory. In the LMP1 category, factory teams - or 'works' cars - must be hybrids. In 2017, the Porsche 919 Hybrid and the LMP1-H from Toyota will be the works cars on the starting grid. The GT-class vehicles, on the other hand, must be based on a road-approved series-production car, although the regulations do permit extensive changes to the specification.

- In the LMP1 class, the cars compete for the official title of the Manufacturers' World Endurance Champion and Drivers' World Champion. The drivers' title is shared by the drivers who won it in a single car. A new addition to the program for the 2017 season is that a world champion title will also be on offer for manufacturers and drivers in the GTE class.

- The points system basically works in the same way as in Formula 1. The first ten to finish are awarded points: 25-18-15-12-10-8-6-4-2-1.

- Half a point is awarded to any finisher outside the top ten.

- Double points are awarded at Le Mans, and achieving pole position in any race is rewarded with an extra point.

- The race at Le Mans lasts 24 hours; the other eight world championship races last six hours. Parts of the races take place in the dark.

- The joint qualifying for LMP1 and LMP2 vehicles lasts just 20 minutes. Two drivers take part in the qualifying round. An average is calculated of the two best lap times (the best time from each driver).

- For the races, the regulations stipulate a minimum and maximum driving time for each driver. In six-hour races, the minimum driving time is 40 minutes, and the maximum time is four and a half hours. In Le Mans, each driver must spend at least six hours behind the wheel. However, no individual driver may drive for more than four hours in any six-hour period or for more than 14 hours over the entire course of the race. If the outside temperature on the day of the race exceeds 32 degrees Celsius, no individual driver may drive for longer than 80 minutes at a time if the car is not fitted with an air-conditioning system. A rest break of at least 30 minutes must be taken between stints behind the wheel on any such days.

- The pit stop procedures are complex. Unlike in Formula 1, the crew and equipment permitted at pit stops are subject to strict limitations. The regulations set out a number of rules, including that the engine must be switched off during a pit stop, only two persons may be involved in refuelling, the vehicle must not be jacked up during refuelling, tyres may only be changed after refuelling, only four mechanics may work on the vehicle at any one time and only one wheel gun may be used on the vehicle at a time.

- Access to the pit lane is limited to a small group of persons appointed to carry out specific tasks. All persons present must wear flame-retardant overalls and a helmet; this rule also applies to photographers and camera crews.

- In the event of an accident or other problems on the track during the race, the WEC uses “full course yellow” (FCY) phases as an alternative to the deployment of a safety car. If a full course yellow is issued, all drivers must slow to 80 km/h (50 mph) and maintain the distance between their vehicle and the driver in front. Pit stops are permitted. Action may be taken to neutralise the race only on specific sections of the track. In such cases, the speed limit of 80 km/h (50 mph) applies only in the “slow zones”. If the safety car does need to be deployed in spite of these measures, the pit lane is closed for three laps. During this period, the pit lane may only be accessed in an emergency – for example to spend five seconds refuelling or to change a damaged tyre.

- The number of rain tyres is unlimited for LMP1, but a limited number of slicks is available. In six-hour races, the limit is three sets (12 tyres) for the free practice sessions and four sets (16 tyres) for qualifying and the race itself. These figures represent an overall reduction of three sets compared to 2016. As in previous years, two single tyres are also available for use in the event of damage.

- For cost control reasons, vehicles in the LMP1-H class are subject to a limit of five new engines per vehicle per season (including Le Mans). The engines must be of the same type; this regulation prevents any engines being developed specifically for individual circuits.

- Since 2015, the regulations have assumed an average weight of 80 kilograms per driver in full race clothing. Teams must compensate for driver weights below this figure using ballast. In spite of this rule, lighter drivers still retain some level of advantage, but the measure aims to prevent teams from favouring particularly lightweight drivers and to remove the incentive for drivers to starve themselves in order to lose weight.

- Drivers must be able to demonstrate – in spite of the limited space available in the cockpit of a closed LMP1 racing car – that they can exit the car in full race clothing within seven seconds through the driver side door and within nine seconds through the passenger side door. As a further measure to protect drivers, the cockpit temperature is constantly monitored.

- Test days for LMP1 are subject to the following limitations: Teams may conduct private tests on a maximum of seven days per calendar year. Subject to the provision of 30 days' notice, teams may conduct tests "in public" on a further ten days. The largest portion of the permitted test days – a further 23 days – must be announced 90 days in advance and must be open to competitors. A test day consists of a maximum of nine hours' driving in a single vehicle. Continuous driving for a period of 24 hours is permitted only during endurance testing. If two vehicles are tested on the same test day, the team is deemed to have used two test days. The official joint tests (the Prologue, the Le Mans pre-test and the Rookie Test at the end of the season) count towards the test day allocation. A maximum of 1,376 tyres (slicks and rain tyres) are available per calendar year and works team for the entire test program. In addition, a maximum of 40 private function tests (roll-out) are permitted. In these tests, no individual car may be driven for longer than one hour a day, and the tests must be conducted using transport tyres.

- Detailed specifications are also in place for wind tunnel tests; these tests are monitored and, as of 2017, are limited to 800 hours.

- Furthermore, for cost control purposes, the maximum number of on-location team members for races after Le Mans is limited to 65 persons for a two-car team.

- Press conferences: After qualifying, the two pole-position drivers for each class are available. After each race, the top-three driver crews in the overall classification and the class winners participate in the press conference.

- The WEC is an audience-friendly event: The paddock is open to holders of standard entry tickets, which are sold at reasonable prices; there are ample autograph sessions and teams are strictly forbidden from obscuring the public's view of the vehicles in any way during the official public pit walks. The 2017 regulations have been tightened up even further: The rules now explicitly state that neither team members nor vehicle parts may be positioned around the racing car in a way that obstructs the public's view of it.

Porsche 919 Hybrid

The technology of the Le Mans prototype

In the world of motorsport, regulatory advisors and race engineers collaborate in a mutually beneficial relationship of balance: As one party puts the brakes on a high-speed Le Mans prototype for safety reasons, the other party works to compensate for the losses. The Porsche engineers' approach to this push-and-pull challenge? Increase efficiency – relentlessly.

The 2017 model of the Porsche 919 Hybrid deploys a range of new innovations, particularly in the vehicle's aerodynamics, the chassis and the combustion engine.

"For the 2017 season, 60 to 70 per cent of the vehicle is newly developed", reports team principal Andreas Seidl. "The basic concept of the 919 Hybrid still offers scope to optimise the finer details and further boost efficiency. The monocoque has remained unchanged since 2016, but the optimisation potential of all other components was analysed and, in most cases, adjustments made accordingly." As in Formula 1, the monocoque is made from a carbon-fibre compound using a sandwich design.

Aerodynamics

The technical regulations for the 2017 FIA WEC World Endurance Championship introduce further limitations in terms of the dimensions of some body components that affect aerodynamics. In an effort to increase safety, the new measurements reduce the downforce of the LMP1 prototypes, which in turn lowers the vehicle's cornering speed for safety reasons. Based on the new specifications and developmental findings, the Porsche engineers devised two brand-new aerodynamics packages for the 919 Hybrid – driven, of course, by a desire to compensate for the increased lap times resulting from the regulatory requirements.

In 2016, Porsche delivered three aerodynamics packages for the season, but the new regulations have also imposed limits on numbers. Andreas Seidl: "Limiting teams to two aerodynamics packages per season is a sensible cost-control measure".

One of the new aerodynamics packages is specifically designed for the high-speed track at Le Mans. To achieve maximum top speeds on the extremely long straight sections, the package design focuses on minimising air resistance. The second aerodynamics package compensates for a higher level of drag with greater downforce for tracks with twists and turns. Track-specific fine-tuning is still permitted, but in general, 2017 will involve a higher level of compromise than was the case with the three aerodynamics packages of the previous year.

A key focus for the engineers was to design the front end of the vehicle to be less aerodynamically sensitive. Seidl continues: “In 2016, the front end of the vehicle was accumulating small amounts of abraded rubber from the track surface. This rubber built up and upset the balance of the vehicle. We analysed this phenomenon and optimised the relevant bodywork components.”

When comparing a front view of this year’s 919 to the previous year’s model, the higher, wider and longer wheel arches immediately catch the eye. To the side, the new channel from the monocoque to the wheel arch is visible, along with the redesigned rear air intakes for the radiators.

“As a result of the aerodynamic losses we will incur due to the new regulations, we are expecting to see a three to four-second increase in lap times at Le Mans,” explains Seidl. “We will have to wait and see how well the various enhancements we have made will compensate for these losses.”

Drive system

As part of the package of enhancement measures, the Porsche engineers have boosted the efficiency and performance of the drivetrain. The transmission on the front and rear axle, the combustion engine, the electric motor and the energy recovery systems have all been optimised, but the basic principle behind the drive system is unchanged: The rear axle of the 919 is driven by an extremely compact two-litre V4 combustion engine. The engine combines downsizing turbo technology with efficient direct fuel injection; it delivers just under 500 hp (368 kW) and is the most efficient combustion engine in the history of Porsche to date. Two different energy recovery systems – a braking energy recovery system on the front axle plus an exhaust energy recovery system – feed a lithium-ion battery, which in turn powers an electric motor capable of supplying additional power of over 400 hp (294 kW) to the front axle on demand. The 919 Hybrid, developed in Weissach, is the only prototype to recover energy during acceleration as well as braking. It achieves a system power of more than 900 hp (662 kW), profiting from the enormous traction generated when the car accelerates out of bends with a further 400 hp of power on the front axle, transforming the 919 into an all-wheel drive.

Approximately 60 per cent of the recovered energy comes from the KERS (Kinetic Energy Recovery System) on the front-axle brakes. The remaining 40 per cent is generated by the exhaust energy recovery system. An average of 80 per cent of the braking energy recovered from the front axle is immediately converted to drive energy. If the combustion engine was required to supply this electrical power, it would need to boost its output by over 100 hp (74 kW), which would increase

the fuel consumption of the 919 by more than 20 per cent. At Le Mans, this would equate to an extra litre of fuel per lap. A further advantage of the highly efficient recuperation system is that it enables the 919 to perform with smaller and lighter brakes – a characteristic that not only reduces weight, but also air resistance, as smaller brakes require less cooling air.

To recover exhaust energy, a small turbine is fitted in the exhaust tract. This turbine runs at a speed of more than 120,000 rpm, powering a generator. Just like the energy recovered from the front brakes, the energy generated is stored in the lithium-ion battery until it is needed. The driver can access this stored energy on demand at the push of a button – using it to boost the car as it speeds out of a cornering manoeuvre while simultaneously replenishing the energy from the exhaust gas generated during acceleration. To ensure that the turbine functions just as efficiently at lower speeds, when exhaust pressure is low, the turbine features variable turbine geometry. In spite of the sophisticated technology on board, the engineering team was still able to achieve a weight reduction in the exhaust system.

“Our aim was to ensure that the vehicle weight did not exceed that of the previous year’s vehicle, in spite of the innovative new technologies we added – from chassis and body elements through to the powertrain updates,” Seidl adds.

The 919 will start again in the highest energy efficiency class prescribed by the regulations. This means that the car can use 8 megajoules of recovered energy over the 13.629-kilometre (8.4 mile) track in Le Mans, subject to the restriction that it may only consume a maximum of 4.31 litres of fuel to do so. Both consumption values are closely monitored and totalled up after each lap.

Driving quality and tyres

Alongside the mechanical enhancements made to the chassis, a number of software innovations have helped to further improve the driving quality of the 919, particularly in terms of traction control and hybrid management. Both of these factors have a significant impact on the service life of the tyres, and this consideration is set to take on even greater importance in 2017. LMP1 teams will now have three sets of tyres fewer available to them for each race weekend and car, so tyre sets will need to withstand double stints of racing on a more frequent basis – lasting the equivalent of two tanks of fuel, or a driving time of around one and a half hours. Andreas Seidl: “Working together with our partner Michelin, we have prepared intensively so that we are able to keep up the pace right through to the end of the race, even when we’re driving in double stints. All the races, whether six hours or 24 hours in duration, will be real sprints to the finish this year, too.” During the night at Le Mans, when temperatures are cooler, even quadruple stints on one set of tyres are possible.

Porsche 919 Hybrid

Specifications

Monocoque:	Composite material structure consisting of carbon fibre with an aluminium honeycomb core. The cockpit is closed.	
Combustion engine:	V4 engine (90 degree cylinder bank angle), turbocharged, 4 valves per cylinder, DOHC, 1 Garrett turbocharger, direct petrol injection, fully load-bearing aluminium cylinder crankcase, dry sump lubrication	
Max. engine speed:	≈ 9,000/min	
Engine management:	Bosch MS5	
Displacement:	2,000 cm^3 (V4 engine)	
Output:	Combustion engine:	< 500 PS, rear axle
	MGU:	> 400 PS, front axle
Hybrid system:	KERS with a motor generator unit (MGU) mounted on the front axle; ERS for recuperation of energy from exhaust gases. Energy storage in a liquid-cooled lithium-ion battery (with cells from A123 Systems)	
Drive system:	Rear wheel drive, traction control (ASR), temporary all-wheel drive at the front axle via the electric motor when boosted, hydraulically operated sequential 7-speed racing gearbox	

Chassis:	Independent front and rear wheel suspension, push-rod system with adjustable dampers	
Brake system:	Hydraulic dual-circuit brake system, monoblock light alloy brake calipers, ventilated carbon fibre brake discs (front and rear), infinitely variable control of braking force distribution by driver	
Wheels and tyres:	Forged magnesium wheel rims from BBS; Michelin Radial tyres, front and rear: 310/710-18	
Dimensions/weights:	Minimum weight:	875 kg
	Length	4,650 mm
	Width:	1,900 mm
	Height:	1,050 mm
Fuel tank capacity:	62.3 litres	

Porsche Motorsport LMP Team

Fritz Enzinger

(Austria)

— Vice President LMP1

"The whole motorsport scene is envious of my team", boasts Fritz Enzinger. His world has revolved around engines and racing for decades. But he built up this Porsche Motorsport LMP Team completely from scratch.

Enzinger, born on September 15, 1956 in the Austrian town of Oberwölz, began to shape Porsche's return to top-level motorsport in late 2011. New premises, new personnel, new car. The biggest successes came four years later: The 17th overall victory for Porsche at Le Mans and winning the manufacturer and driver titles in the FIA World Endurance Championship. And in 2016, under his auspices, the triumph could be duplicated across the board.

The success came faster than expected and can be attributed to Enzinger's considerable experience: He was previously with BMW for thirty years – in corporate strategy, sponsoring, HR structure, team management and driver contracts. He was in positions of responsibility with respect to touring car victories, the overall victory at Le Mans in 1999 and Formula One successes. All of this took place with him as someone in the background, a preference which still applies today. The mechanical engineer's office door is always open to his staff; he is someone who is more comfortable in jeans and a shirt that in a collar and tie. It wasn't the prestigious stage that drew him to Porsche. What attracted him was the tremendous opportunity to be able to shape such a large project from its infancy.

When he has a free weekend he returns to his family in Munich. Icelandic horses are the hobby that help him unwind with his wife and daughter.

Porsche Motorsport LMP Team

Andreas Seidl

(Germany)

— Team Principal

Silverstone, the beginning of the 2014 season – the team principal has the start of the very first race with the Porsche 919 Hybrid ahead of him: “A small step for mankind, but a big step for Porsche – we have two LMP1s on the grid.” There’s a lot resting on Andreas Seidl’s shoulders and his dry sense of humour acts as a refreshing release valve. As team principal, Seidl, who was born on January 6, 1976 in Passau, Germany, is a decathlete of sorts. As an engineer with a perfectionist streak he is responsible for the technical performance of the cars; as race manager he’s responsible for the organisational aspects of a world championship race. To the squad of LMP1 drivers he is akin to a national coach; he heads up Business Relations as a manager and ambassador; and as chief of strategy he makes crucial decisions together with the race engineers. He loves the interdisciplinary challenge, the ultimate endurance test and the relentless feedback. Performance is laid bare for all to see, and this is particularly true when taking part in Le Mans. To battle for overall victory with a racing team that he has shaped from the very beginning is one of his life-long dreams.

Strategic planning on the basis of if-then scenarios is part of Seidl’s belief system. He does not believe in chance or bad luck. From schedules to pit stops – everything is planned to the finest detail. There is no area that escapes him; no detail is too small to be ignored if it could be relevant to Porsche’s performance.

Until 2009 Seidl was responsible for Formula One testing and racing at BMW Sauber. After BMW’s withdrawal from Formula One, he managed the company’s DTM comeback. He fully committed himself to this, which helped the company to win the title at its first attempt in 2012. After that, the Porsche LMP1 programme came as a huge but welcome new challenge for the father of two. Progress was slow-going at the beginning, but the world championship title and the Le Mans victory in 2015 and 2016 were spectacular successes. He would never claim these victories for himself. It’s always the team that counts.

Porsche Motorsport LMP Team

Neel Jani

(Switzerland)

— The cool one

"In some ways it's a shame that I now sit in the same car as André", says world champion Neel Jani about his new team mate Lotterer, "because we used to have some nice battles. But on the other hand it's great of course to now have him by my side." Super-fast, super-cool – the two virtuosos respected each other as opponents and are now allies against the rest of the field. Jani and Lotterer have had the same fitness trainer for years, are both world champions, Le Mans winners and former Formula One test drivers. "And with Nick Tandy we now have a third Le Mans winner on board," stresses Jani. "Nick took the 2015 victory in the third car almost from nowhere." In 2016, Jani has now achieved two rather significant career goals: the world championship title and the overall Le Mans victory with Porsche. And now? "Now I know how it feels – and I want more of it!"

Weekend excursions in a Porsche have always been a passion of his. "I have great memories of when I was a kid," says Jani. "On Sundays I would climb into the back of my father's 911 2.7 RS with my sister Reena and he would take us out walking. We absolutely loved these outings. Unfortunately we later had to sell the car because my racing was so expensive."

Coming up through Formula Renault, the GP2 and A1GP series, Jani marched towards Formula One. He tested for Red Bull Racing for the first time in 2004 and in 2006 he became the stand-in driver for sister team Toro Rosso. He took part in test days and demo drives and raced in the American Champ Car and A1GP series. In 2008 he made an appearance as a guest driver in the Porsche Supercup. "Unfortunately I didn't finish the race", he remembers, "but I did get to drive a 911 GT3 RS for two weeks beforehand. That was quite an experience for me as a 24 year old. The car had so much power but could still be controlled so precisely, very impressive indeed." Calculation and precision are part of his very being. When asked what job he would have had if he hadn't become a racing driver, he says: "An accountant. I like numbers."

He drove at Le Mans for the first time in 2009 and has done so every year since – with Rebellion in the LMP1 class up until 2013. With the team he won the Le Mans Series in 2011 and in 2012 he just missed out on a podium finish in Le Mans, coming fourth overall. In 2012 and 2013 he took victory in the ten-hour race at Road Atlanta, better known as Petit Le Mans. He's been a Porsche factory driver since June 2013. "A huge opportunity to be part of Porsche's return from the very start!"

The first test drives with the 919 were difficult from a technical perspective and the 2014 début season had tough patches, but alongside Romain Dumas and Marc Lieb, Jani took the first three pole positions and the maiden victory for the innovative Porsche prototype. In 2015 there were technical problems in Le Mans, the third car won and at the end of the season it was the sister car's crew that became world champions. Unfinished business was starting to pile up for Jani, but he remained calm and collected. "I believe in karma", he says, "that helps. Everything happens when it's supposed to happen and what goes around comes around. In 2016 at Le Mans, and later in the world championship final, I was rewarded for the effort I'd put in previously."

Vita

Date of Birth:	8th December 1983
Place of Birth:	Rorschach (CH)
Nationality:	Swiss
Residence:	Port (CH)
Height/weight:	1.72 m/62 kg
Marital status:	Married to Lauren
Hobbies:	Sports, cross-country skiing, tennis, cycling
Website:	www.neel-jani.com
Twitter:	@neeljani
Le Mans starts:	8 (1 overall victory)

Neel Jani competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours race, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1 31st overall Daytona 24 Hours (Rebellion)
2016	Porsche works driver WEC, LMP1 Drivers' World Champion with Dumas/Lieb, Overall race victory Le Mans 24 Hours, race win (Silverstone), pole position (Le Mans)
2015	Porsche works driver WEC, LMP1 3rd Drivers' World Championship, 1 win (Bahrain), 5 second places, 2 pole positions including qualifying lap record in Le Mans, 5th Le Mans 24 Hours
2014	Porsche works driver WEC, LMP1 1st São Paulo, 2nd Bahrain, 3rd Shanghai Pole positions Spa, Shanghai, Bahrain
2013	1st Road Atlanta "Petit Le Mans" (ALMS, overall) 3rd Sebring 12 Hours (ALMS, overall) 2nd Laguna Seca (ALMS, overall) 2nd Long Beach (ALMS, overall) Porsche works driver since June
2012	1st Road Atlanta "Petit Le Mans" (ALMS, overall) 4th WEC (overall) 4th Le Mans 24 Hours (overall)
2011	Winner Le Mans Series (LMP1) 6th Le Mans 24 Hours (overall) Formula One show runs (Red Bull Racing)
2010	3rd Le Mans Series (LMP1, Rebellion) Le Mans 24 Hours Formula One show runs (Red Bull Racing) GT1 Championship (3 races) Superleague Formula (2 races, 1 win)

2009	Le Mans 24 Hours (LMP1) Formula One tests (Red Bull Racing)
2008/09	2nd A1GP (4 wins)
2008	Formula One tests (Red Bull Racing) Porsche test (LMP2)
2007/08	Winner A1GP Series (4 wins)
2007	ChampCar World Series (3 podium finishes)
2006	Formula One test and reserve driver (Scuderia Torro Rosso)
2005/06	2nd A1GP series
2005	GP2 series (2 wins)
2004	Formula Renault V6 Eurocup (5 wins) Formula One test (Red Bull Racing)
2003	2nd Formula Renault V6 Eurocup (4 wins) Formula One test (Sauber-Petronas)
2002	2nd Formula Renault 2000 Eurocup (3 wins)
2001	Formula Renault 2000 Eurocup Italian Formula Renault
2002	Winner Formula Lista Junior, Switzerland
1996–2000	Karting

Porsche Motorsport LMP Team

André Lotterer

(Germany)

— The newcomer

Because the ultra-fast prototypes are so much quicker than the GT vehicles, there's always a lot of talk about differences in speed in the World Endurance Championship. André Lotterer is surprising in his own way for operating at different speeds: Inside the racing car, the name of the three-time Le Mans winner and 2012 world champion is synonymous with top speed and the overtaking prowess that goes with it. But outside the cockpit he sheds any sign of being in a hurry. With an imposing and deliberate way of speaking, stressful rushing about is not part of the equation.

His first drive at Le Mans was in 2009, in an Audi for the Kolles team. He quickly established himself in endurance racing with the Ingolstadt-based brand, while continuing his formula career in Japan. In 2014 he made a brief excursion into Formula 1, and in 2017 Lotterer will drive for Porsche for the first time. The first thing that comes to mind about his new employer: "It's the sportiest brand of the lot and the stuff of legend at Le Mans. When little kids draw a sportscar, it's often a Porsche 911. I was no different." This was even more so the case because of his circumstances at home: The Lotterer family moved to Belgium when his father was given the opportunity to build a racing team as Technical Director. Various Porsches were used in the team. In Nivelles, south of Brussels, André Lotterer still feels at home. This is where his mother lives and it is also where he keeps his collection of cars – housed in an industrial area that was developed on the site of a former Formula One racetrack. The collection includes four Porsches: a Carrera GT, two 2.7 RSs from 1973 and a 964 3.8 RS.

In Germany, the town of Renningen is his first port of call, located a stone's throw from Weissach and the ancestral home of his mother's side of the family. "When I was a teenager there was one time in Weissach when I was allowed to sit in one of the first Porsche GT1s, while my father was in a meeting with Norbert Singer", he recalls. There is not just one place that André Lotterer calls home: Alongside the family outposts and his testing and racing duties, he lives between his homes in Monaco and Tokyo. After a year as a Formula One test driver (2002), his life centred around Japan, where he drove in Formula Nippon and Super GT at the same time. It wasn't until 2009 that he reappeared in Europe with Audi.

He regards his 2011 Le Mans victory as his greatest achievement: “For a start, because it was the first one – and you never know if you’ll be able to pull it off again. And because the victory came about in such unusual circumstances: The lead had changed hands more than 40 times. I came in for my last pit stop at the same time as the Peugeot. Leaving the pits I had a six second advantage and my team mates and I ultimately won by 13 seconds. I had five stints in the car, almost four hours. It was one hell of a race. Allan McNish and Mike Rockenfeller were involved in accidents in the two sister cars. The night was bad, we were really worried. The garage doors had been left down. It was just me, Marcel Fässler and Benoît Tréluyer going up against the Peugeot. We were the only Audi to finish the race. This is the victory that I’ll never forget.”

Vita

Date of Birth:	19th November 1981
Place of Birth:	Duisburg (DE)
Nationality:	German
Residence:	Tokyo (JP)
Height/weight:	1.84 m/74 kg
Marital status:	Single
Hobbies:	Riding and building lightweight racing bikes, photography, food, collecting and taking classic cars out for a spin, trips out in the sticks in the buggy
Twitter:	@Andre_Lotterer
Le Mans starts:	8 (3 overall victories)

André Lotterer competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours race, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1
2016	5th place WEC (Audi), two 2nd place finishes (Mexico City, Bahrain), one 3rd place (Nürburgring), 3 pole positions (Silverstone, Nürburgring, Austin); 3rd place Superformula in Japan
2015	2nd place WEC (Audi), 2 wins (Silverstone, Spa); 3rd place Superformula
2014	2nd place WEC (Audi), overall victory Le Mans 24 Hours, race win in Austin; 3rd place Superformula
2013	2nd place WEC (Audi), 3 wins (Spa, São Paulo, Shanghai); 2nd place Superformula
2012	Drivers' World Champion WEC (Audi), overall victory Le Mans 24 Hours, wins Silverstone and Bahrain; 4th place Formula Nippon, 6th place Spa 24 Hours (Audi)
2011	overall victory Le Mans 24 Hours (Audi); 1st place Formula Nippon
2010	2nd place Le mans 24 Hours (Audi); 2nd place Japanese Super GT Championship; 2nd place Formula Nippon
2009	3rd place Formula Nippon; 1st place Japanese Super GT Championship; 7th place Le Mans 24 Hours (Audi); 24 Hours Nürburgring, one race A1GP series
2008	3rd place Formula Nippon; 3rd place Japanese Super GT Championship

2007	4th place Formula Nippon; 6th place Japanese Super GT Championship
2006	3rd place Formula Nippon; 1st place Japanese Super GT Championship
2005	4th place Formula Nippon; 9th place Japanese Super GT Championship
2004	2nd place Formula Nippon; 8th place Japanese Super GT Championship
2003	4th place Formula Nippon (Rookie of the Year); Japanese Super GT Championship
2002	Formula One test driver (Jaguar); 3rd place Spa 24 Hours; one ChampCar race
2001	7th place British Formula 3, 2nd place Formula 3 Masters Zandvoort
2000	4th place German Formula 3
1999	1st place Formula BMW ADAC; 5th place Formula Renault Eurocup
1998	1st place Formula BMW ADAC Junior Cup
1989–97	Karting, 1st place Junior Kart World Championship 1995

Porsche Motorsport LMP Team

Nick Tandy

(Great Britain)

— Feet firmly on the ground

Nick Tandy stood stock-still in the pit lane on June 14, 2015. Tears ran down his face, and media crews had a hard time getting full sentences out of him. Moments previously, along with Nico Hülkenberg, who drove the 919 over the finish line, and Earl Bamber, he had become winner of Le Mans. “It took a while before I could take it in,” he admits. “This win changed my life. Within Porsche in that they brought me back from the GT programme when a regular place in the LMP1 team became free for 2017. And outside of the world of Porsche too. In England this race is revered as one of the greatest in the world. You’re not just seen as a racing driver any more, but as a Le Mans winner.”

Making the transition from the 911 RSR to the 919 Hybrid has not proved too difficult for him, as the events of 2015 emphatically demonstrated. “The biggest difference is the aerodynamic downforce at high speeds. And of course operating the hybrid is more complicated. But when it comes down to it,” says the consistently modest pro, “the 919 is also a racing car with two pedals, a steering wheel and four wheels.” He used the test drives at the start of 2017 to get to grips with the enhanced hybrid racing car in detail.

Nick Tandy grew up on a farm in Pavenham, a small village in the county of Bedfordshire, and the rural surroundings and community spirit helped shape him. Now a young father, he still lives nearby. When his schedule allows, he helps his parents on the farm and with the harvest, or attends to the fortunes of the racing team JTR, which was founded by his brother Joe, who died in a car accident in 2009. These days JTR competes in the Porsche Carrera Cup Great Britain.

Nick’s career began in 1996 with short oval stock cars and led the amateur golfer and mountain biker into Formula 3 by way of the Formula Ford. In a guest stint in the Porsche Carrera Cup Great Britain in 2008, he managed to secure his first win in his first race. In 2011, he took the title in the Porsche Carrera Cup Germany. In 2012, he won the prestigious Porsche Cup as the most successful driver worldwide in a 911.

In 2013, he secured third place in the Sebring Classic 12 Hour, this time as a works driver in the 911 RSR. After this he won the GT class in the European Le Mans Series race in Budapest, and celebrated another big success with a GT victory in the Petit Le Mans on the challenging traditional track Road Atlanta. The next highlight in the 911 RSR was a class victory in the 24 Hours of Daytona in 2014. When Porsche gave some of their GT drivers the opportunity to test the 919,

he gave a convincing performance and won himself a place in what was then the third car in the line-up for Le Mans. Spurred on by a magnificent victory on the Sarthe, in 2015 he managed yet another spectacular achievement: In the most adverse weather conditions, competing in the 911 RSR against stronger prototypes, he took the first overall victory for Porsche in the Petit Le Mans. As concerns expectations for the 2017 season, he simply points to the facts: "We're now three Le Mans winners in a world champion team."

Vita

Date of Birth:	5th November 1984
Place of Birth:	Bedford (GB)
Nationality:	British
Residence:	Bedford (GB)
Marital status:	married to Brittany, one daughter (Eva), one son (Felix)
Height/Weight:	1.78 m/71 kg
Hobbies:	badminton, darts, golf, iRacing
Twitter:	@NickTandyR
Le Mans starts:	4 (1 overall victory)

Nick Tandy competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours race, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1
2016	Porsche works driver, GT 2nd Sepang 12 Hours (Intercontinental GT Challenge); IMSA SportsCar Championship: class win GTLM Long Beach, 2nd place class GTLM Austin
2015	Porsche works driver overall victory Le Mans 24 Hours, overall victory Petit Le Mans Road Atlanta, 3 class wins TUSC GTLM (Bowmanville, Road America, Virginia)
2014	Porsche works driver 1st Daytona 24 Hours (GTLM) 2nd WEC Silverstone (GTE-Pro)
2013	Porsche works driver 1st Petit Le Mans (ALMS, GT) 3rd Sebring 12 Hours (ALMS, GT) 3rd European Le Mans Series (GT) 1st Silverstone, Budapest (ELMS, GT)
2012	Winner Porsche Cup 2nd International GT Open, 5 wins 3rd team classification ADAC GT Masters, 4 wins
2011	Winner Porsche Carrera Cup Deutschland, 3 wins 5th Porsche Mobil 1 Supercup, 1 win, 6 podiums Porsche Carrera Cup Great Britain, 3 wins
2010	2nd Porsche Carrera Cup Deutschland, 5 wins
2009	10th British Formula 3 Championship, 1 win, 3 podiums
2008	9th British Formula 3 Championship, 3 podiums Porsche Carrera Cup Great Britain (1 race, 1 win)

2007	3rd British Formula Ford Championship, 6 wins, 16 podiums Winner Formula Ford Festival Winner Formula Palmer Audi Autumn trophy Finalist McLaren Autosport BRDC Award
2006	2nd British Formula Ford Championship, 3 wins, 11 podiums
2005	Winner BRDC Single Seater Series, 11 wins Winner Silverstone Scholarship
1996–2004	Short Oval Stock Cars (British Champion 1999 and 2000) and Mini Se7en Championship (Champion 2003)

Porsche Motorsport LMP Team

Earl Bamber

(New Zealand)

— The shooting star

"I found it hard not being able to compete for the overall victory in Le Mans in 2016," Earl Bamber confesses. After his monumental success in the Porsche 919 Hybrid on June 14, 2015, when together with Nico Hülkenberg and Nick Tandy he secured the brand's 17th overall victory, he had returned to Porsche's GT programme. But the memory of the high point of his career to date has remained fresh: "It was an overwhelming feeling, holding that cup in my hands and being applauded by so many people," says the New Zealander. "If you were dreaming about winning Le Mans, that would normally be the moment when you'd wake up. I was amazed that in real life the dream kept going." For the 2017 season, he is back at the wheel of the Porsche Class 1 prototype and now shares it as a regular driver with fellow countryman Brendon Hartley and old hand Timo Bernhard.

"Timo is a great guy, and two kiwis in one car – of course that's something pretty special. Brendon and I grew up in the same kart club." His sense of anticipation is huge, as is his respect for others in the race: "Toyota will be a really tough opponent, and our sister car will be very strong as well."

Bamber accomplished his rise to the top tier of endurance racing in record time. As winner of the Porsche Motorsport International Cup Scholarship, one of the most wide-ranging and thorough youth development schemes in the automotive industry, in 2014 he took both the overall victory in the Porsche Mobil 1 Supercup and, for the second time in a row, in the Carrera Cup Asia. Time and again, he has impressed: in Barcelona when he won his début race in the Supercup; at Silverstone when he came in third despite a mistake in qualifying; at Spa when he controlled the car after a sideways skid coming out of Eau Rouge and still took the victory. And in his first race in the 911 RSR, he also put up a convincing performance, coming in second in the Petit Le Mans, the American endurance classic held at Road Atlanta. On the basis of these wins, in December 2014 he was promoted to works driver for the new season.

It was looking good. But it was going to get even better: One day before Christmas, he received an invitation to test the Porsche 919 Hybrid in Abu Dhabi in January 2015. "A tremendous honour," he recalls. "Every racing driver in the world wanted to drive this car." Bamber quickly got to grips with the complex prototype, was soon achieving good lap times – and was promptly put in the LMP1 squad.

Earl Bamber has chosen to take up residence in Kuala Lumpur. In terms of flight miles, the Malaysian capital sits roughly halfway between his home in New Zealand and the home of Porsche. Bamber grew up on a farm, 75 kilometres from the nearest town of Whanganui on the southern tip of the North Island. Wellington is two hours away. He has been sitting behind a wheel since the age of two. First he steered his dad's pick-up truck as far as the post box sitting on his father's lap, and later he drove karts and single seaters. "The development I got through Porsche was the big opportunity of my racing career," he says. "And after the Le Mans win in 2015, I've reached a new level in all areas."

Vita

Date of Birth:	9th July 1990
Place of Birth:	Wanganui (NZ)
Nationality:	New Zealander
Residence:	Kuala Lumpur (MAL)
Marital status:	Single
Height/Weight:	1.83 m/74 kg
Hobbies:	fitness, surfing, skiing
Internet:	www.earlbambermotorsport.com
Twitter:	@earlbamber
Le Mans starts:	2 (1 overall victory)

Earl Bamber competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1
2016	Porsche works driver, GT IMSA SportsCar Championship: 1 win (Austin, four 3rd place finishes (Daytona, Sebring, Laguna Seca, Virginia); 4th FIA GT World Cup Macau; 2nd Sepang 12 Hours (Intercontinental GT Challenge)
2015	Porsche works driver overall victory Le Mans 24 Hours; three 2nd place finishes TUSC, class GTLM: Watkins Glen, Road America, Virginia
2014	Winner Porsche Motorsport International Cup Scholarship Winner of the Porsche Mobil 1 Supercup (2 wins, 7 podiums) Winner of the Porsche Carrera Cup Asia (8 wins, 10 podiums) 2nd Petit Le Mans (GTLM) Porsche Carrera Cup Deutschland (2 wins)
2013	Winner Porsche Carrera Cup Asia (4 wins, 8 podiums) Winner Audi R8 LMS Cup Korea 2nd Porsche Mobil 1 Supercup Abu Dhabi
2012	3rd World Time Attack Challenge (overall)
2011	7th Superleague Formula 10th World Time Attack Challenge 3rd Porsche GT3 Cup Challenge race in New Zealand
2010	2nd Toyota Racing Series NZ (6 wins) Winner New Zealand Grand Prix
2009	A1GP Series for New Zealand (3 podiums, A1GP award for best overtaking move) GP2 Asia Series

2008	Winner Toyota Racing Series International Championship 2nd Toyota Racing Series NZ 2nd Formula Renault V6 Asia,
2007	7th Toyota Racing Series NZ 11th Formula Renault V6 Asia
2006	Winner Formula BMW Asia (10 wins)
2005	4th Formula Ford NZ
2004	Karting

Porsche Motorsport LMP Team

Timo Bernhard

(Germany)

— The old hand

Fast, in great physical condition, extremely team-oriented, always wide awake and fully informed – Timo Bernhard is a safe pair of hands. He is the poster boy for endurance sport – it's about so much more than your own good lap times. He has won all of the big endurance races: Daytona, Sebring, he even took overall victory five times in the 24 Hours Nürburgring. In 2010, on loan to Audi at that time, he became overall winner at Le Mans with Romain Dumas and Mike Rockenfeller. In 2015, alongside Brendon Hartley and Mark Webber, he was world endurance champion with Porsche.

He remembers his first Porsche drive in 2002 at the Circuit de la Sarthe when he won the GT class. "Back then there was such a clamour to make a return to the top category – I realised that Porsche and Le Mans belong together in a way which is unparalleled. The past three years in LMP1 have been challenging, unbelievably exciting and very emotional. An overall victory at Le Mans with this brand would be the icing on the cake."

It has already seemed to be in reach three times with Hartley and Webber: In 2014, when he took the lead after 20 hours. On that occasion, the Porsche 919 Hybrid had to retire two hours before the end of the race due to problems with the drivetrain. In 2015, when the car dominated the first third of the race, before the trio were set back by a stop-and-go penalty. And in 2016 when a water pump defect robbed the three drivers of their chance of victory.

Bernhard is the longest-serving of all the Porsche factory drivers. He started his successful career in 1999 as a junior and to date he is the only factory driver who has become champion in all categories of the Porsche pyramid: In 2001 he won the Porsche Carrera Cup Deutschland, in 2004 the GT title in the American Le Mans Series, in 2007 and 2008 he became LMP2 champion with the RS Spyder and in 2015 world champion with the 919 Hybrid. He has turned to Porsches for rally drives in a private capacity time and time again. As a side job with his father Rüdiger, he runs Team 75 Bernhard which also prefers Porsche.

Bernhard has been involved from the beginning, including during the tough stages of the test phase for the LMP1 programme. He also guided newcomers Hartley and Webber during the difficult initial period. In this way, the three vastly different drivers have grown unusually close. They became three friends, two of whom were sad to see Webber step down. In 2016 the trio mastered a season that

began sluggishly but in which four victories were carved out. Earl Bamber is the new third man in 2017. “I do like to look back but I prefer to look ahead”, says Bernhard. “In Brendon and Earl I now have two bright sparks at my side. I can benefit from that and I’m happy to pass on my experience.”

On July 12, 2013, Bernhard led the rollout with the first 919 Hybrid. “It was not only a new Le Mans race car, it was a Porsche!” He recalls: “When I drove into the village 15 years ago in my first factory car, kids were standing at the side of the road. I couldn’t hear them but I could read their lips: That’s a Porsche!” The trophy cabinet is bursting at home in Bruchmühlbach-Miesau, but family is the most important thing here. Timo and his wife Katharina became parents for the second time in 2016.

Vita

Date of Birth:	24th February 1981
Place of Birth:	Homburg/Saar (D)
Nationality:	German
Residence:	Bruchmühlbach-Miesau (D)
Marital status:	Married to Katharina, sons Paul and Ben
Height/Weight:	1.74 m/60 kg
Hobbies:	Fitness, music, rally, running
Internet:	www.timo-bernhard.de
Twitter:	@Timo_Bernhard
Le Mans starts:	10 (1 overall victory)

Timo Bernhard competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1
2016	Porsche works driver WEC, LMP1 4th Drivers' World Championship with Hartley/Webber, 4 wins (Nürburgring, Mexico City, Austin, Shanghai) 1 pole position (Spa)
2015	Porsche works driver WEC, LMP1 Drivers' World Champion with Hartley/Webber, 4 wins (Nürburgring, Austin, Fuji, Shanghai), 2nd Le Mans 24 Hours, 3 pole positions,
2014	Porsche works driver WEC, LMP1 3rd Silverstone, Fuji and Bahrain 1 pole position (São Paulo)
2013	Porsche works driver 2nd Le Mans 24 Hours (GT) 1st Nürburgring 24 Hours (SP7 class, 7th overall) LMP1 test programme 1st ADAC Saarland Rally (German Rally Championship)
2012	Porsche works driver 2nd Sebring 12 Hours (overall) Endurance Cup Nürburgring-Nordschleife, 2 podiums
2011	Porsche works driver 1st Nürburgring 24 Hours (overall) 5th Sebring 12 Hours (overall) Le Mans 24 Hours (LMP1)
2010	Porsche works driver 1st Le Mans 24 Hours (overall, Audi) ADAC Motorsport Personality of the Year

2009	Porsche works driver 1st Nürburgring 24 Hours (overall) 4th Grand-Am Series (DP), 4 podiums Le Mans 24 Hours (LMP1)
2008	Porsche works driver Winner American Le Mans Series (LMP2), 4 wins 1st Sebring 12 Hours (ALMS, overall) 1st Nürburgring 24 Hours (overall)
2007	Porsche works driver Winner American Le Mans Series (LMP2), 8 wins 1st Nürburgring 24 Hours (overall)
2006	Porsche works driver 3rd American Le Mans Series (LMP2), 4 wins 1st Nürburgring 24 Hours (overall)
2005	Porsche works driver 2nd American Le Mans Series (GT2), 5 wins 2nd Le Mans 24 Hours (GT2)
2004	Porsche works driver Winner American Le Mans Series (GT), 2 wins 1st Sebring 12 Hours (ALMS, GT) 1st Petit Le Mans (ALMS, GT) 3rd Nürburgring 24 Hours (overall) 2nd Spa 24 Hours (N-GT)
2003	Porsche works driver 2nd American Le Mans Series (GT) 1st Petit Le Mans (ALMS, GT) 1st Daytona 24 Hours (overall) 1st Nürburgring 24 Hours (overall)

2002	Porsche works driver 3rd Porsche Michelin Supercup 4th American Le Mans Series (GT) 1st Daytona 24 Hours (GT) 1st Le Mans 24 Hours (GT) 2nd Nürburgring 24 Hours (overall)
2001	Porsche Junior Winner Porsche Carrera Cup Deutschland 2nd Sebring 12 Hours (ALMS, GT) Porsche Pirelli Supercup, 1 win

2000	Porsche Junior 3rd Porsche Carrera Cup Deutschland
1999	Porsche Junior 12th Porsche Carrera Cup Deutschland 3rd German Formula Ford Championship
1998	6th German Formula Ford Championship, 2 wins 6th Formula Ford Euro Cup
1991–1997	Karting

Porsche Motorsport LMP Team

Brendon Hartley

(New Zealand)

— Full fledged

"I had the best teachers in the world," says Brendon Hartley of the past three years with Timo Bernhard and Mark Webber. The New Zealander came into the Porsche LMP1 programme as a fledgling for the 2014 season. Even his entrance was original: an unsolicited application by email to the team manager. "Being allowed to compete for the overall victory in Le Mans as a Porsche works driver, it's so huge, I can hardly find the words," says the 2015 world champion. "Winning there with this brand is my ultimate goal."

At the age of 25, Hartley became part of an unequal trio: Bernhard was the Porsche man and well-established endurance pro. Webber had 215 Formula 1 Grand Prix and nine wins under his belt. Youth, experience, celebrity – everything was thrown into a pot unreservedly, mixed together with the indisputable speed of all three drivers, and out came a particular blend, known as friendship. Hartley shed tears when Webber stepped down. He came to maturity in this triumvirate. Hair trimmed; wings grown.

When he first turned up in Formula 1 in 2008, with his blonde mane and baggy jeans, he looked more like a budding rock star than a test driver. In fact he does play guitar, but beneath the 19-year-old's cool outfit was a shy person with 13 years of racing experience. He started karting at the age of six, inspired by his father Bryan. Brendon's big brother Nelson, named after Nelson Piquet, was ten when Brendon was allowed to drive for the first time. The older boy was faster, and the younger can still today recall the sleepless night that followed. "Ever since then I knew I loved racing and knew of the desire I had inside to win."

In his home country of New Zealand, Brendon Hartley got into formula racing. He grew up in Palmerston North on the North Island and drove in the same kart club as his new team mate Earl Bamber – there are adorable photos of the two of them on the farm. Following series wins in the Formula Ford and further successes, it was clear that he lived at the wrong end of the world for a continuing career. At the age of 16 he jumped in at the deep end. He set up camp in the east of Germany and drove in the German and European Championships in the Formula Renault 2.0; in 2007 he won the World Series by Renault. A formative time in a foreign country and in the tough talent factory of Red Bull.

In 2008, he managed to pull off a stunning feat at the Formula 3 Grand Prix in Macau: Position 20 on the grid, third over the finish line, fastest lap. All the same, he was flabbergasted when the call came from Red Bull asking if he could stand in for the injured Webber in a Formula 1 test. And he did well. 83 laps are an ordeal for a neck being exposed to these levels of force for the first time. He moved from Germany to Milton Keynes, where they at least spoke his language.

He held a Formula 1 contract up to and including the year 2013 – first as a test driver for Red Bull Racing, and then for the Mercedes team. He was much valued for his simulator work. But a racing driver has to drive races. In 2012, his second career in endurance racing gathered speed. The European Le Mans Series, Grand Am, Bathurst 12 Hour, 24 Hours of Daytona and in Le Mans. “The first time I drove a race wearing Porsche overalls in 2014, I almost burst with pride,” recalls the tall New Zealander. “Becoming world champion with Mark and Timo was huge. But winning the Le Mans with Porsche is still to come.”

Vita

Date of Birth:	10th November 1989
Place of Birth:	Palmerston North (NZ)
Nationality:	New Zealander
Residence:	Monaco (MC)
Height/weight:	1.84 m/65 kg
Hobbies:	mountain biking and road cycling
Internet:	www.brendonhartley.co.nz
Twitter:	@BrendonHartley
Le Mans starts:	5

Brendon Hartley competes in the FIA World Endurance Championship (WEC), including the Le Mans 24 Hours, in a Porsche 919 Hybrid for Porsche.

Career

2017	Porsche works driver WEC, LMP1 overall victory Dubai 24 Hours (Porsche 911 GT 3 R); 17th overall Daytona 24 Hours (Nissan prototype)
2016	Porsche works driver WEC, LMP1 4th Drivers' World Championship with Bernhard/Webber, 4 wins (Nürburgring, Mexico City, Austin, Shanghai) 2 pole positions (Spa, Shanghai)
2015	Porsche works driver WEC, LMP1 Drivers' World Champion with Bernhard/Webber, 4 wins (Nürburgring, Austin, Fuji, Shanghai), 4 pole positions, 2nd at Le Mans
2014	Porsche works driver WEC, LMP1 3rd Silverstone, Fuji and Bahrain
2013	European Le Mans Series (LMP2) Grand Am Series Le Mans 24 Hours (LMP2) Bathurst 12 Hours Daytona 24 Hours Formula One simulator development driver (Mercedes AMG Petronas)
2012	3rd Spa (WEC, LMP2) 3rd Donington (ELMS, LMP2) GP2 (2 races) Formula One simulator development driver (Mercedes AMG Petronas)
2011	World Series by Renault 3.5 (4 podiums) 5th Spa (GP2)
2010	Formula One reserve driver (Red Bull Racing, Scuderia Toro Rosso) World Series by Renault 3.5 GP2 (2 races)

2009	Formula One test driver (Scuderia Toro Rosso) World Series by Renault 3.5 Formula 3 Euro Series (1 win) Macau Formula 3 Grand Prix
2008	Formula One test driver (Red Bull Racing) 3rd British Formula 3 Championship (5 wins, 12 podium finishes, 5 poles) 3rd Macau Formula 3 Grand Prix (also set fastest lap) 5th Zandvoort Formula 3 Masters
2007	Winner World Series by Renault Eurocup 2.0 (5 wins, 13 podium finishes, 7 poles) 3rd Italian Formula Renault 2.0 series 4th Zandvoort Formula 3 Masters Macau Formula 3 Grand Prix
2006	Winner Dan Higgins Memorial Trophy, New Zealand Toyota Racing Series, New Zealand
2005	Winner of the first ever Toyota Racing Series race in New Zealand Winner of the Elite Motorsport Academy Award, New Zealand
2004	Awarded with the Steel Trophy, New Zealand
2003/04	2nd New Zealand Formula Ford Championship (6 wins) Winner Formula Ford Winter Series (7 wins) Youngest ever winner of a Formula Ford race (23rd November 2003)
2002/03	Karting

Porsche Motorsport LMP Team

Key personnel at a glance

Vice President LMP1	Fritz Enzinger
Team Principal	Andreas Seidl
Chief race engineer	Stephen Mitas
Race engineer car number 1	Jeromy Moore
Race engineer car number 2	Kyle Wilson-Clarke
Crew Chief	Amiel Lindesay
Manager Motorsport Press LMP	Holger Eckhardt

Porsche Motorsport LMP Team

Stages in fast motion from 2011 to 2017

End of 2011 Recruiting begins (status those days: Fritz Enzinger plus five more employees).

2012 An office building and the workshop are built. Timo Bernhard and Romain Dumas are announced as the first drivers.

12.06.2013 Roll-out of the first 919 Hybrid on the test ground in Weissach with Timo Bernhard at the wheel.

2013 Testing on various race tracks in different countries, team preparation in Weissach going on with, for example, 1,053 pit stops practiced. Drivers Neel Jani, Mark Webber, Brendon Hartley and Marc Lieb are announced.

The team under Fritz Enzinger, Vice President LMP1, grows to 230 people. Alexander Hitzinger is Technical Director, Andreas Seidl becomes Team Principal.

February 2014 The driver combinations are confirmed: Berhard/Hartley/Webber and Dumas/Jani/Lieb.

04.03.2014 Presentation of the Porsche 919 Hybrid alongside the 911 RSR at the International Auto Salon in Geneva.

20.04.2014 Podium finish at the race debut: Bernhard/Hartley/Webber come third at the six-hour race at Silverstone.

02.05.2014 First pole position in the second race: Jani/Lieb dominate qualifying in Spa-Francorchamps.

15.06.2014 Le Mans: Marc Lieb crosses the line in 11th place overall. Less than two hours before the car was fourth when it had to pit for a long repair because of a gearbox issue. Almost at the same time, Mark Webber, second in the race, had to give up due to an engine failure. Both 919 Hybrids had problems earlier in the race as well (fuel system No 14, suspension No 20), but caught up brilliantly. Towards the end of the race car number 20 was leading for a long time.

12.10.2014 In Fuji a 919 sets the fastest race lap for the first time (Webber).

15.11.2014 For the first time both car crews make it onto the podium: In Bahrain Dumas/Jani/Lieb finish second in front of Bernhard/Hartley/Webber.

25.11.2014 Announcement to enter a third Porsche 919 Hybrid in Spa and Le Mans in 2015.

November 2014 Porsche signs Nico Hülkenberg to drive a third 919 Hybrid in Spa and Le Mans in 2015.

29.11.2014 For the first time the two 919s lock out the front row: In São Paulo Bernhard/Webber manage to achieve the fourth pole position for the 919 Hybrid.

30.11.2014 In São Paulo Dumas/Jani/Lieb achieve the maiden win for the 919. It is the sixth podium finish in the debut season and a success under dramatic circumstances, because Mark Webber suffers a heavy accident with less than 30 minutes race time left. Luckily he escapes without any severe injuries.

15.12.2014 First roll-out of the 2015 Porsche 919 Hybrid on the test ground in Weissach with Marc Lieb at the wheel.

05.02.2015 In Paris Porsche announces Earl Bamber and Nick Tandy will complete the crew for the third 919 Hybrid.

26.03.2015 Presentation of the second generation Porsche 919 Hybrid in Paul Ricard.

12.04.2015 In Silverstone both 919s lock out the front row of the grid. Pole position goes to Bernhard/Hartley/Webber, who retire from the race. Dumas/Jani/Lieb finish second.

02.05.2015 In Spa, three 919s are fielded for the first time – serving as a dress rehearsal for Le Mans. They occupy the first three grid spots with Bernhard/Hartley Webber again as pole-sitters. The trio finishes the race in third behind Dumas/Jani/Lieb. LMP1 newcomers Bamber/Hülkenberg/Tandy achieve sixth.

10.06.2015 In the first qualifying at Le Mans, two of the 919s break the seven-year-old qualifying record. Fastest is Jani with a lap time of 3.16.887 minutes ahead of Bernhard.

11.06.2015 Tandy puts the third 919 third in the second qualifying session at night.

14.06.2015 Bamber/Hülkenberg/Tandy clinch the 17th overall victory for Porsche at Le Mans. Bernhard/Hartley/Webber make the one-two result perfect. It is the fourth for Porsche after 1971, 1987 and 1998. Dumas/Jani/Lieb conclude the spectacular race in fifth. Now, after three World Championship rounds, and scoring double points at Le Mans, Porsche leads the manufacturers' category of the World Championship.

30.08.2015 The next one-two result follows at the first WEC race in Germany: Bernhard Hartley/Webber win on the Nürburgring ahead of Dumas/Jani/Lieb, who finish in second place despite several stop-and-go penalties. In qualifying, this order was reversed. The new aero kit of the 919 generates significantly more downforce.

19.09.2015 In Austin, Bernhard/Hartley/Webber win again, after starting from second on the grid. Pole went to Dumas/Jani/Lieb, who finish the race in fifth after an electronic problem.

11.10.2015 Despite difficult weather conditions, Fuji yields the third one-two: Bernhard Hartley/Webber in front of Dumas/Jani/Lieb. The two 919s started the race in this order. Thanks to swapping positions shortly before the end of the race, Bernhard/Hartley/Webber move into the lead of the Drivers' World Championship.

01.11.2015 With one race left on the calendar, Porsche holds an unassailable lead in the manufacturers' classification. With Bernhard/Hartley/Webber notching up the fourth win of the season in Shanghai, and Dumas/Jani/Lieb again in second, they secure the World Championship title for Porsche. Pole position went to the eventual race winners.

21.11.2015 Porsche wraps up the season at the finale in Bahrain by scoring the sixth overall victory in a row and takes home the drivers' title. Fifth for Bernhard Hartley/Webber is enough to clinch the Drivers' World Championship. Dumas Jani/Lieb secure their long-awaited first win of the season. The race turne into a thriller. Holding a 13-point advantage over the fastest Audi trio,

Bernhard/Hartley/Webber had started from pole position. But after 30 minutes, the three pitted for lengthy repairs and had to make up ground, charging from last to fifth place. It was the sister car that grabbed the lead from the fast Audis in Bahrain, and thus snatched the decisive championship points. In the 2015 season, no other car managed to start from the front row of the grid other than the 919.

23.03.2016 Presentation of the developed 919 in Paul Ricard, the successful driver line-up remains unchanged.

17.04.2016 Dumas/Jani/Lieb (4th on the grid) finish second at the season opener in Silverstone. Because of the number 7 Audi being disqualified, they are promoted to the race winners. Jani clocks the fastest race lap. Bernhard Hartley/Webber (3rd on the grid) retire after two hours due to an accident when lapping a slower car (Hartley).

07.05.2016 Despite hybrid problems, Dumas/Jani/Lieb come second in Spa, the same position they had started from. Bernhard/Hartley/Webber only finish fifth in the LMP1-H class after tyre damage had huge consequences. Hartley manages the fastest lap of the race, after he had started from pole position.

19.06.2016 After a strategic duel with a Toyota, which went on for hours, Dumas/Jani/Lieb take the 18th overall Le Mans victory for Porsche. The finish was dramatic: Kazuki Nakajima in the leading Toyota stops on track with one lap to go. Bernhard/Hartley/Webber finish 13th overall, having been delayed by long repairs (water pump). Jani and Bernhard had started from the front row of the grid.

24.07.2016 On home soil at the Nürburgring Bernhard/Hartley/Webber repeat their previous year's win, having started third on the grid. After some unscheduled pit stops, Dumas/Jani/Lieb (4th on the grid) finish fourth. They defend their championship lead in the drivers' standings.

03.09.2016 Bernhard/Hartley/Webber win the WEC debut race in Mexico City, having started from fourth. Hartley sets the fastest race lap. For Dumas/Jani/Lieb the tyre strategy in changing conditions doesn't work out, and they have an incident in traffic. They finish fourth, but still extend their championship lead.

17.09.2016 In hot tropical conditions in Austin, Bernhard/Hartley/Webber take their third consecutive race win, having started third. Dumas/Jani/Lieb start fifth on the grid, suffer for a long time from a lack of downforce and, again, finish fourth. They remain championship leaders, but the advantage has shrunk.

16.10.2016 In the best track conditions in Fuji the 919 returns to the front row of the grid: P2 for Bernhard/Hartley/Webber, P6 for Dumas/Jani/Lieb. 0.025 seconds is the gap to pole position. In the race the gap between the winning Toyota and the second placed Audi is 1.4 seconds. Bernhard/Hartley/Webber finish third, the championship leaders only come fifth. Their advantage has melted again. It is an emotional weekend because on Thursday Webber announces his retirement from professional racing at the end of the season. He becomes a Porsche representative.

06.11.2016 In Shanghai Bernhard/Hartley/Webber perform a straightforward start-to-finish victory from pole position with Hartley setting the fastest race lap. Dumas Jani/Lieb start from P6 on the grid and finish fourth. Porsche wins the World Championship title for Manufacturers the second time in a row.

19.11.2016 Mission accomplished: In the last one of the nine WEC rounds, held in Bahrain, Dumas/Jani/Lieb become the new Drivers' World Champions, despite finishing the race after an early collision in sixth position. They had started from P3 on the grid. Bernhard/Hartley/Webber (P2 on the grid) come third in the race.

03.12.2016 After the fare well of Webber, Dumas and Lieb Porsche announces its new driver line-up for the 2017 WEC and Le Mans: Neel Jani shares the number 1 car with newcomer André Lotterer and LMP1 homecomer Nick Tandy. The number 2 sister car is now in the hands of Timo Bernhard, Brendon Hartley and Earl Bamber (who alongside Tandy is the second Porsche works driver and 2015 Le Mans winner returning to the LMP1 programme).

31.03.2017 Unveiling of the reworked Porsche 919 Hybrid at the Italian race track of Autodromo Nazionale di Monza.

The balance sheet after the Porsche 919 Hybrids' 25 outings since early 2014 and including the 2016 season is:

- 15 pole positions
- 13 victories, including four one-twos
- eight fastest race laps
- four world championship titles (two for manufacturers, two for drivers)

Twelve manufacturers' titles in earlier Sports Car World Championships:

1964, 1969, 1970, 1971, 1976, 1978, 1979, 1982, 1983, 1984, 1985, 1986

LMP1 Porsche 919 Hybrid

Results WEC 2014

	#14 Dumas/Jani/Lieb		**#20 Bernhard/Hartley/Webber**	
	Qualifying	Race	Qualifying	Race
6 Hrs Silverstone winner's distance: 167 laps (red flag)	3rd place (DUM/JAN) 1:43.087	DNF (failure)	6th place (BER/WEB) 1:43.226	3rd place -2 laps
6 Hrs Spa winner's distance: 171 laps	**1st place** (JAN/LIE) 2:01.198	4th place -1 lap (failure)	5th place (BER/HAR) 2:03.672	23rd place -23 laps (failure)
24 Hrs Le Mans winner's distance: 379 laps	2nd place (DUM) 3:22.146	11th place -31 laps (failure)	4th place (BER) 3:22.908	DNF (failure)
6 Hrs Austin winner's distance: 157 laps	2nd place (DUM/JAN) 1:50.283	4th place -1 lap (failure)	3rd place (HAR/WEB) 1:50.302	5th place -2 laps
6 Hrs Fuji winner's distance: 236 laps	3rd place (JAN/LIE) 1:27.306	4th place -2 laps	2nd place (BER/WEB) 1:26.929	3rd place -1 lap
6 Hrs Shanghai winner's distance: 188 laps	**1st place** (DUM/JAN) 1:48.300	3rd place -1 lap	3rd place (HAR/WEB) 1:48.324	6th place -2 laps (tyre damage)
6 Hrs Bahrain winner's distance: 195 laps	**1st place** (DUM/JAN) 1:43.145	2nd place -50.460 sec	3rd place (BER/HAR) 1:44.191	3rd place -57.268 sec
6 Hrs São Paulo winner's distance: 249 laps	2nd place (JAN/LIE) 1:17.783	**1st place**	**1st place** (BER/WEB) 1:17.676	accident (WEB)

Final World Championship positions 2014:

3rd place for Porsche in the manufacturers' championship (193 points)
3rd place for Dumas/Jani/Lieb in the drivers' championship (117 points)
9th place for Bernhard/Hartley/Webber in the drivers' championship (64,5 points)

LMP1 Porsche 919 Hybrid

Results WEC 2015

	#17 Bernhard/Hartley/Webber		**#18 Dumas/Jani/Lieb**		**#19 Bamber/Hülkenberg/ Tandy**	
	Qualifying	Race	Qualifying	Rennen	Qualifying	Race
6 Hrs Silverstone winner's distance: 201 laps	**1st place** (HAR/WEB) 1:39.721	DNF (gearbox)	2nd place (DUM/JAN) 1:40.340	2nd place -4.61 sec	–	–
6 Hrs Spa winner's distance: 176 laps	**1st place** (BER/HAR) 1:54.767	3rd place -1 lap	3rd place (JAN/LIE) 1:55.284	2nd place -13.424 sec	2nd place (HÜL/TAN) 1:55.025	6th place -3 laps
24 Hrs Le Mans winner's distance: 395 laps	2nd place (BER) 3:17.767	2nd place -1 lap	**1st place** (JAN) 3:16.887	5th place -1 lap	3rd place (TAN) 3:18.862	**1st place**
6 Hrs Nürburgring winner's distance: 203 laps	2nd place (BER/WEB) 1:36.542	**1st place**	**1st place** (DUM/LIE) 1:36.473	2nd place -1 lap	–	–
6 Hrs Austin winner's distance: 185 laps	2nd place (BER/HAR) 1:46.375	**1st place**	**1st place** (JAN/LIE) 1:46.211	12th place -17 laps (electrics)	–	–
6 Hrs Fuji winner's distance: 216 laps	**1st place** (BER/WEB) 1:22.763	**1st place**	2nd place (DUM/LIE) 1:23.071	2nd place -14.306 sec	–	–
6 Hrs Shanghai winner's distance: 169 laps	**1st place** (HAR/WEB) 1:42.719	**1st place**	2nd place (DUM/LIE) 1:43.488	2nd place -26.294 sec	–	–
6 Hrs Bahrain winner's distance: 199 laps	**1st place** (HAR/BER) 1:39.736	5th place -9 laps	2nd place (DUM/LIE) 1:40.100	**1st place**	–	–

Final World Championship positions 2015:

1st place for Porsche in the manufacturers' championship (344 points)
1st place for Bernhard/Hartley/Webber in the drivers' championship (166 points)
3rd place for Dumas/Jani/Lieb in the drivers' championship (138,5 points)

LMP1 Porsche 919 Hybrid

Results WEC 2016

	#1 Bernhard/Hartley/Webber		**#2 Dumas/Jani/Lieb**	
	Qualifying	Race	Qualifying	Race
6 Std. Silverstone Siegerdistanz: 194 Runden	3rd place (HAR/WEB) 1:54.150	DNF (accident)	4th place (DUM/JAN) 1:54.266	**1st place**
6 Std. Spa Siegerdistanz: 160 Runden	**1st place** (BER/HAR) 1:55.793	26th place -48 laps (failure)	2nd place (JAN/LIE) 1:56.590	2nd place -2 laps
24 Std. Le Mans Siegerdistanz: 384 Runden	2nd place (BER) 3:20.203	13th place -38 laps (failure)	**1st place** (JAN) 3:19.733	**1st place**
6 Std. Nürburgring Siegerdistanz: 194 Runden	3rd place (BER/WEB) 1:39.861	**1st place**	4th place (JAN/LIE) 1:39.893	4th place -1:37.324 min
6 Std. Mexiko Stadt Siegerdistanz: 230 Runden	4th place (HAR/WEB) 1:25.400	**1st place**	2nd place (JAN/LIE) 1:25.111	4th place -1:30.004 min
6 Std. Austin Siegerdistanz: 186 Runden	3rd place (BER/HAR) 1:46.560	**1st place**	5th place (DUM/JAN) 1:47.331	4th place -1 lap
6 Std. Fuji Siegerdistanz: 244 Runden	2nd place (BER/WEB) 1:23.595	3rd place -17.339 sec	6th place (JAN/LIE) 1:24.134	5th place -1 lap
6 Std. Shanghai Siegerdistanz: 195 Runden	**1st place** (HAR/WEB) 1:44.462	**1st place**	6th place (JAN/LIE) 1:45.051	4th place -1:40.855 min
6 Std. Bahrain Siegerdistanz: 201 Runden	2nd place (BER/HAR) 1:39.471	3rd place -1:17.001 min	3rd place (JAN/LIE) 1:39.669	6th place -3 laps

Final World Championship positions 2016:

1st place for Porsche in the manufacturers' championship (324 points)
1st place for Dumas/Jani/Lieb in the drivers' championship (160 points)
4th place for Bernhard/Hartley/Webber in the drivers' championship (134,5 points)

In focus

Race strategy: a high-paced game with many unknowns

On June 17/18 in 2017, Porsche will be competing at the 24 Hours of Le Mans with the 919 Hybrid for the fourth time. In 2015 as well as in 2016 the team has won this classic. To master all the decision making two times around the clock, the racing strategists in the Porsche Motorsport LMP Team need maximum control. Not only of the two highly complex prototypes, many other factors have to be calculated into the process as well.

The protagonists

Team Principal Andreas Seidl is a Bavarian by birth and a strategist by calling. Together with the engineering staff – Chief Race Engineer Stephen Mitas (AUS) and Vehicle Race Engineers Jeromy Moore (AUS, car number 1) and Kyle Wilson-Clarke (GB, car number 2) – Seidl plans the optimum approach ahead of the race like a chess player in countless 'what-if' scenarios. After the race begins, however, the game is a question of reactions. It depends on the correct decision for each situation.

Factor 1: The refuelling stop

The first limiting parameter in planning the race is the distance between the refuelling stops. Since the maximum consumption values for fuel and electrical energy per lap are specified in the WEC, the latest point for refuelling is known. The strategists also know this information for their rivals' vehicles. On the 13.629 kilometre (8.4 mile) lap in Le Mans, the Porsche 919 Hybrid covered 13 laps with a full tank of 62.5 litres.

During the 24-hour race it will not be possible to divide the distance covered at the end exactly by these 13 laps. However, the aim is for the car to cross the finishing line with practically the last drop of fuel. This is because the less fuel there is in the tank, the lighter and faster the car will be. Consequently, at some point in time there will be a refuelling stop where the tank is not filled completely. The most suitable point for this to happen needs to be well thought-out. If a race proceeds without any incidents, this short refuelling stop is saved to the end. However, any changes in the weather or neutralisation phases may result in time savings if the stop is brought

forward and combined, for example, with a change to rain tyres. The decision is made within seconds. A simulation programme, that is constantly fed with information, helps in the process. The data comes from the team's own cars, observations of the competitors and the meteorologists.

Factor 2: The tyre change

The second basic parameter for the racing strategy is the performance curve of the tyres, which is where the expertise of the Michelin engineers comes to bear. The greater the wear on the tyres, the worse the lap times will be. This deterioration must be weighed up against the time lost by a tyre change in the pits. Tyre degradation does not always take place in a linear manner. Sometimes the rubber experiences a low point after a few laps, but then recovers again. At the same time, the car becomes lighter with every lap – this can also have the effect of extending tyre life. Andreas Seidl quotes figures: "In Le Mans in 2016, our longest distance with one set of tyres was 53 laps. This means we refuelled three times without changing the tyres. From their best to their worst performance – adjusted for the effects of fuel – the tyres lost roughly 1.4 seconds per lap. The difference in weight of 44 kilos between full and empty tank accounts for about two seconds per lap."

Speed on the circuit and length of pit stops are crucial in covering the greatest distance of all in 24 hours. In 2016, the team refuelled the winning car 30 times in Le Mans. Including entry and exit, the fastest refuelling stop took 65.2 seconds and the shortest pit stop, including driver and tyre change, 1:22.5 minutes. The drivers always have to stay the course for as long as the tyres permit. A stop just to relieve a driver would be a loss in time. But how long can a driver hold out without becoming slower?

Factor 3: The racing drivers

"All our drivers are totally-fit, full professionals and are capable of a quadruple stint in the night," Seidl points out. "However, we also have to keep an eye on the driving times." The regulations stipulate a minimum and maximum driving time for each driver. At Le Mans, every driver has to spend at least six hours at the wheel, but must not drive more than four hours within any six and a maximum of 14 hours over the entire distance. Normally this is not a problem. But what happens if a driver has stomach problems? These are "what-if" scenarios that can decide the race. Seidl: "We try to give the drivers optimum rest periods and allow ourselves as much flexibility as possible right through to the end."

Team Principal, race engineers and drivers discuss who sits at the wheel when. There is the frequently combative starting phase, which calls for a cool head. There are long stints in the night, and the prestigious task of driving over the finishing line. Seidl: "We try to plan everyone in to the optimum and to be fair as well, because the mood in the team also has an impact on performance."

Factor 4: The accident

However the race evolves, turns round or surprises, the simulation software helps in delivering an interpretation. At any time, the team is able to read how it will fare if the race continues as normal and also receives valuable tips by computer on dealing with any unscheduled events. For instance, does it make sense to bring forward a pit stop if a Full Course Yellow period is announced or if the safety car is deployed? The programme also computes the strategic consequences of a possible repair stop. If a car has contact with a rival, the tyre pressures and aerodynamic data are checked instantly, the driver provides feedback by radio. Looking at the damage though is something that neither he nor the race engineers at the pit wall are able to do with the car flashing by at over 200 km/h (124 mph). This takes place on monitors in what is called the "Battle Room" behind the scenes. Sometimes a slow-motion repeat is needed to show whether the car needs a pit stop.

Factor 5: The pit crew

The pit crew is always on standby for any stops that become necessary at short notice. And they are fast: in 2016, the overall time spent in the pit lane by the winning Porsche 919 Hybrid during the Le Mans 24-Hours, including entry and exit along the pit lane, amounted to 38 minutes and 5 seconds. Just the choreography for the stops is a science in itself. This is because, in contrast to Formula 1, an unlimited number of mechanics are not allowed to work on the car, and fewer makes things difficult. The regulations have been tightened up further for 2016. Details are listed on 11 pages. They include stipulations such as the requirement that only two people are allowed to refuel, that the car has to be standing on its wheels during this process, that wheels cannot be changed until after refuelling, that no more than four mechanics and one wheel gun may be used at the same time on the car during this operation and much more – including a list of penalties. The team works out when which step and which manoeuvre is to be performed and considers who should take on each individual role. Dry runs then follow in the workshop. More than 250 stops mount up there alone per season. Added to this are the practices during testing and on the race weekends themselves. A wheel with tyres weighs 19.9 kilograms, so the mechanics have to be strong, swift and stress-resistant.

Petrol consumption, tyre wear, ease of maintenance and service in the pits: many things are calculable, some can be tested and others can be practiced. Yet, the strategists will never be able to cover everything that may happen in 24 hours with their “what-if” scenarios. Or as world champion and 2016 Le Mans winner Neel Jani puts it: “You cannot win Le Mans. Le Mans lets you win.”

In focus

Hybrid and high voltage technology

By way of the 919 Hybrid, Porsche has developed a new field of technology at racing speed. For the concept study “Mission E” (project name “J1”), the brand’s first fully electric road-going sports car unveiled in 2015, the designers adopted the 800-Volt technology from the LMP1 racer.

Porsche has exhausted all technical possibilities for the two times Le Mans winning car. This goes especially in terms of the drive concept. It consists of a two-litre, V4 turbocharged petrol engine, the most efficient combustion motor that Porsche has built up to now, and two different energy recovery systems.

During braking, a generator at the front axle converts the car’s kinetic energy into electrical energy. In the split into two exhaust system, one turbine drives the turbocharger while another converts surplus energy into electrical energy. The braking energy contributes 60 per cent, with the remaining 40 per cent coming from exhaust gas pressure. The recuperated electrical energy is stored temporarily in a lithium-ion battery and feeds an electric motor on demand. “On demand” means: the driver wants to accelerate and calls up the energy at the press of a button. In accordance with the latest regulation changes, the power from the combustion engine is under 500 hp (368 kW), and the output from the electric motor is well over 400 hp (294 kW). The result is a system power of more than 900 hp (662 kW).

The use and interplay of these two energy sources require a sophisticated strategy. In every braking phase, energy is won – that is, recuperated. On the 13.629-kilometre (8.4 mile) lap of Le Mans this happens 38 times, before every corner. Sometimes more, sometimes less – depending on the severity of the braking manoeuvre, or in other words, the speed at which the driver arrives at the corner and how tight it is. Braking and recuperation last until the apex of every corner, the driver then accelerates again. In this moment, the aim is to utilise as much energy as possible. Hence, the driver steps on the throttle pedal using fuel energy, and also “boosts” electrical energy from the battery. While the combustion engine drives the rear axle, the electric motor takes care of the front axle. The 919 catapults out of the corner without any loss of traction using all-wheel drive and a significant amount of extra power – and in the process recuperates energy again. The Porsche 919 Hybrid is the so far only existing Le Mans prototype that recovers energy not just under braking but also when accelerating.

This is done by the extra turbine in the exhaust tract. Particularly on the extremely long Mulsanne Straight, where the 919 exceeds 330 km/h (205 mph), the turbine is hard at work. At high engine speeds, the pressure in the exhaust system increases rapidly and drives the turbine. It revs more than 120,000 times per minute and is connected directly to an electric generator. Thanks to VTG

technology – this means variable turbine geometry, able to adapt to current exhaust gas pressure – the turbine also works efficiently at low engine revs and accordingly low gas pressure. This aspect makes the technology relevant for road going cars and Porsche is still the only manufacturer to utilise turbochargers with variable turbine geometry in petrol engines.

Both energy sources, however, are limited by the WEC regulations: a driver may not use more than 4.31-litres of fuel and no more than 2.22 kilowatt hours of electricity on a lap in Le Mans (13.629 kilometres / 8.4 miles). He must calculate this carefully so that at the end of the lap he has used exactly this amount – no more, no less. He who uses more is penalised. He who uses less, loses performance. He must stop "boosting" and lift his foot off the throttle at exactly the right moment.

The 2.22 kilowatt hours of electrical energy correspond to eight megajoules – and that is the highest energy class stipulated in the regulations. Porsche was the first manufacturer who dared to push the limits so far.

For the concept choice a very close look at the individual alternatives was taken. There was no question that Porsche would use the braking energy at the front axle. For the second system brake energy recuperation at the rear axle or through utilising exhaust gas were considered. Two aspects pointed in favour of the exhaust solution: Firstly weight, and then efficiency. With brake energy recovery, the system has to recuperate energy within a very short space of time, which means coping with a lot of energy, but at the expense of weight. The acceleration phases, however, are much longer than the braking phases, which allow a longer period of recuperation and make the system lighter. Plus with the combustion engine the 919 already has a drive system on the rear axle. Even more power at the rear would have generated more inefficient wheel spin. When the rear axle struggles to deal with too much power and cannot convert it into drive, inefficient slip evolves. Moreover, this leads to tyre wear and can even badly damage the rubber.

Arguably Porsche's bravest decision for the hybrid system of the 919 was opting for 800 Volts. Establishing the voltage level is a fundamental decision in electric drive systems. It influences all else – the battery design, electronics design, e-motor design and charging technology. Porsche pushed this as far as possible.

It was difficult to find components for this high voltage, particularly a suitable storage medium. Flywheel generator, supercapacitors or battery? Porsche chose a liquid-cooled lithium-ion battery, with hundreds of individual cells, each enclosed in its own cylindrical metal capsule.

In both a road and racing car, power density and energy density must be balanced. The higher the power density of a cell, the faster energy can be recharged and released. The other parameter, energy density, determines the amount of energy that can be stored. In racing, the cells – figuratively speaking – must have a huge opening. Because as soon as the driver brakes, a massive

energy hit comes in, and when he boosts it must leave at exactly the same speed. An everyday comparison: If an empty lithium-ion battery in a smartphone had the same power density as the 919, it would be completely recharged within a lot less than a second. The downside: A brief chat and it's empty again. So that the smartphone lasts for days, the energy density has priority, and that means storage capacity.

In an electric car for everyday use, storage capacity translates into range. In this regard, the requirements of the racing car and a road-going electric car therefore are different. But with the 919 Porsche has advanced new levels of hybrid management. The 919 served as the testing lab for the voltage level of future hybrid systems.

Important basic knowledge was discovered during the LMP1 programme. Such as cooling for the energy storage (battery) and the electric motor, the connection technology for extreme high voltage as well as the battery management and the systems' design. From this experience, the colleagues in production development gained important expertise for the four-door concept car Mission E with 800-Volt technology. From this concept, a series production road car will appear by the end of the decade.

In focus

The Porsche 919 Hybrid's cockpit – multi tasking at racing speed

With hands and feet, courage, experience and instinct the drivers control the Porsche 919 Hybrid in the FIA World Endurance Championship (WEC). Underneath, the feet play heel-and-toe. Some of the Porsche works drivers use their left foot for braking, others prefer to switch with the right one between throttle and brake. But what they do with their hands is a lot more complicated. The drivers operate 24 buttons and switches on the front as well as six paddles on the reverse side of the steering wheel, plus quite a number of further operating functions on the dashboard. For the 2017 season, several of the buttons and switches were re-positioned in co-operation with the drivers.

The wheel isn't round, but a flat rectangle. The shape is due to the space required during driver changes. Tall drivers such as Brendon Hartley, in particular, would otherwise have difficulties in accommodating their long legs quickly. There is a large display in the upper centre, which shows the driver a multitude of information. This includes the speed, what gear is engaged, the currently selected motor management, and the charge status of the lithium ion battery, i.e. how much electrical energy is available to be called up to drive the front axle. The electric motor on the front axle supplements the turbo charged 2-litre, 4-cylinder combustion engine, which drives the rear wheels.

The most frequently used buttons are positioned along the top outside edge, so they are easy to reach with the thumb. The blue button at the top right is almost always in use – it is the headlight flasher, used by the fast prototypes to warn the slower vehicles in the WEC field before they are lapped. When pushed once, it causes the headlights to flash three times. In daylight, the drivers keep their thumb on it almost permanently, as naturally the headlight signal is more difficult to perceive at that time.

The red button at the top left is also very frequently used. It is used to demand electrical power from the battery, the so-called "boost". The drivers can boost to pass, but must be clever about rationing the power. The amount of energy per lap is specified. The yardstick is one lap in Le Mans, where eight megajoules are available. The amounts are converted accordingly for shorter circuits. The amount of energy a driver uses, for example, in the middle of a lap to get free of traffic will not be available for the rest of the lap.

Underneath the display there are five rotary switches. The orange-rimmed one in the centre is new at this place and controls the amount of energy when boosting. The red-rimmed rotary switch next to it on the left (TC F, traction control at the front axle) also is new there and replaces two buttons. The green rotary switch (RECUP) on the right is for the energy recovery management. The rotaries at the lower left and right (TC/CON and TC R) are for pre-setting the traction control. In the centre of the lowest level sits the on/off switch for the combustion engine (Start/Kill).

To fine tune for various engine and hybrid settings, the drivers use the buttons on the top level, MI- and MI+ in blue. Below them there are the plus and minus buttons in pink to distribute the brake balance (BR) between the front and rear axle. The yellow couple in the next lower row is new there. The "Box" button on the left is for the driver to confirm he has understood and pits now. The "Wipe" button switches the windscreen wiper on and off.

From the green buttons, the left one operates the radio (RAD) and the one on the right hand side is the OK button for the driver to confirm he performed the setting changes requested from him via the pit radio. A multi directional telemetry is prohibited, the engineers are not allowed to interfere actively, they can just give the drivers information and orders from the data they receive.

The red buttons on the next level below operate the drink bottle (left, DRINK) and on the right hand side the sailing mode (SAIL), which is a fuel saving driving mode with no acceleration from the combustion engine.

The orange coloured button PIT on the left hand side engages the speed limiter for the pit lane (60 km/h - 37 mph). Its equivalent on the right hand side is labelled FCY and is the speed limiter for neutralisation periods, as when there is a "Full Course Yellow" all cars have to go at 80 km/h (49.7 mph).

Halfway up on the left there is a golden-yellow control dial marked with an M for Multi. This one corresponds with the two controllers at the very top outside of the steering wheel. When the race engineer, for example, asks for the setting "Alpha 21", the driver chooses "A" with the bigger golden-yellow controller, then he chooses the 2 by the left hand red controller and finally the single digit 1 by the dark green right controller before pressing the OK button. Programmes for engine management or fuel management are designated by such combinations.

The one remaining control dial on the right halfway up the steering wheel offers the strategy choice for the combustion engine (S, blue). To make the switches easier to recognise in the dark, their colours are fluorescent and respond to a black light lamp, which is situated above the driver's helmet.

The steering wheel is made of carbon, the grip handles are covered in slip-resistant rubber. Thanks to the power steering system, drivers can steer the car without any difficulty, even with the relatively narrow grips. When reaching through the openings, their fingers touch six paddles on the reverse side of the steering wheel. The centre paddles are used for changing gears – pulling the right paddle is for upshifting, and pulling the left paddle is for downshifting. The lowermost paddles operate the clutch, the paddles at the top operate the boost; whether the drivers use this paddles or the boost button described on the front is purely a matter of preference.

The steering wheel is running out of space, for further operating functions the drivers have to reach over to the dashboard. This is also where the rotary switch moved to that chooses what information comes on the display. On the dashboard the drivers can dim the display light at night, tune the volume of the radio and the windscreen wiper's speed, put the gearbox into neutral, change to reverse gear, switch on the rain rear light and the cockpit fan and activate the indicators or hazard flashing. Finally on the dashboard the main power switch is located, the ignition switch, the on/off switch for the hybrid system and the one for the fire extinguisher. A new feature in the 2017 cockpit is the rear view camera.

In focus

Aerodynamics

It's a development process that never ends: Engineers work tirelessly to constantly redefine the aerodynamic performance of the Porsche 919 Hybrid. For the 2017 season, the prototype was given a full aerodynamic design facelift. The enhancements were fuelled not only by a drive to improve performance, but also to boost safety: The race regulations are intended to prevent prototypes from reaching irrepressible, ever-increasing speeds while ensuring that the vehicles stay on the track in the event of incidents such as spins.

Each and every minor detail that enlarges or shrinks the front cross-section of the vehicle, which affects the air flow, has a direct impact on lap times. But for Porsche, the lessons learnt on the track today help to optimise air flow in the road vehicles of tomorrow – for lower fuel consumption and even better performance.

Take the car door as an example: The regulations specify a minimum size for the door, which only weighs around three kilograms. The driver must be able to exit via the door within seven seconds. A quick-release system, which allows the door to be released from its hinges, is mandatory for emergencies. The driver door also functions as a support for a headrest structure, which is made from shape memory polymer and covered in aramid fibre composite material. To survive a heavy impact from the driver's helmet, the door frame is subjected to a 700-kilogram cross-directional load, and must remain undamaged and undistorted after the test. A further key factor in aerodynamics: During the race, a low-pressure area builds up to the side of the cockpit, generating up to 60 kilograms of force pulling the door outwards. The frame – made of fibre composite with highly modulated carbon fibres – must be rigid enough for this pressure not to affect the aerodynamics; the door pane itself is made of polycarbonate at least two millimetres thick.

The wheel arches are a further example: At Silverstone, the aperture on the front wheel arch is subtly and smoothly chamfered. At Le Mans, it is tapered in towards the tyres, while on the Nürburgring, it still has a protruding lip. These kinds of finely tuned details are the result of intensive aerodynamic analysis. This is a process with a clear objective in mind – but it is also a process that will never end. There is always room for improvement.

Detail modifications are permitted to a certain extent for each and every track, although from 2017, the regulations limit the use of complete aerodynamics packages to two per season. The design of these packages is orientated towards the specific requirements of Le Mans, with its long straights, on the one hand, and the remainder of the season with the eight more compact tracks

on the other. These tracks require greater aerodynamic downforce; the lower drag has less of an impact on the top speed. The two car bodies differ by up to 80 per cent – yet the variations remain largely invisible to the untrained eye.

On the Le Mans prototype 919 Hybrid, a team of more than 20 aerodynamics engineers works to balance the two sides of the same racing coin: downforce and drag. But what causes downforce? It could be something as simple as a steeply angled front or rear wing profile. If the air flow under the wing profile is faster than the air flow above it, low pressure is created under the profile. This pressure difference generates downforce, which pushes the vehicle down towards the road surface. However, gains in downforce always come at a cost – namely larger air flow contact surfaces. Higher drag will, in turn, bring down the top speed.

And wing profiles are only part of the picture. Every square millimetre of the carbon fibre body of the prototype, every air intake and outlet and every finely finished edge is designed with aerodynamic efficiency in mind. The majority of the details that affect aerodynamics are invisible to the casual observer, hidden under or within the vehicle. The air flows around the entire vehicle and through the vehicle body are complex and interdependent factors, and are exposed to a whole range of driving situations – straight stretches or bends, braking phases, side winds, slipstreams or even vortices created intentionally by driving close together. Due to the conflicting requirements arising in ever-changing driving situations within the same race, it is not feasible to optimise every single detail for every eventuality.

In various stages, the engineers work to determine where the details should be fine-tuned to prioritise downforce, and where it would be more beneficial to reduce drag. Where available, data from previous years plays a key role in this process, and the track profile – its layout, topography, asphalt quality and predicted temperatures – is also important.

Before any body elements for the Porsche 919 Hybrid are developed and constructed as models, CFD (Computational Fluid Dynamics) systems are used to simulate the relationship and interplay between the computed parts. The next step is to construct a model – the Porsche engineers test a 60-per cent model in the wind tunnel of the Williams Formula 1 team in the British town of Grove in Oxfordshire. Only once these tests are complete can components be produced and tested in actual size. Without this rapid prototyping process, parts production would be far too costly and time-consuming. And now the race team at Weissach has yet another asset available: The new 1:1 scale wind tunnel in the Porsche Development Centre, which enables the engineers to test the car in actual size. Whether they are developing series-production cars or racing cars, this technology fosters even closer collaboration between engineers in the discipline of aerodynamics.

In focus

Logistics: Efficient world tour

Entering the two highly complex Porsche 919 Hybrids for the overseas races of the FIA World Endurance Championship does pose logistic challenges for the Weissach based Porsche Team. The air freight is 30 tons. Nevertheless, only indispensible items are taken on board. The team's hospitality, for example, isn't one of the essentials. The works team eats in the paddock canteen.

Air cargo is complex. Like in the classic computer game Tetris, items have to be stacked without gaps, using the aircraft's hold including any sloping sections. The area for the Porsche freight is limited to 12 units. Each of them measures 304 by 230 centimetres and must not exceed the required weight, otherwise the basic costs increase. Months ago it was calculated 12 units would be needed. The cargo list contains several thousand items. In order to ensure that everything fits into the limited space, the team always had the air freight requirements in mind when making decisions over what to purchase – whether for a tool cabinet, packaging for the drivers' helmets, or an engine box. Furthermore, similar to moving house, the rule is: whatever is needed first at the destination, must be immediately available. Perfect organisation is essential to build up the garage on time, and once the team starts unloading a three-ton container in a freight packed pit lane it sits there until it is empty.

For the Porsche Team, ten tailor-made containers have been purchased. Six of them, the so called Q7, have sloping tops, two are the flatter Q6 and two are "winged lowers", shaped especially for the lower cargo space in the aircraft. They are more efficient than anything you can buy ready-made, and save a lot of packing material compared to stacking single boxes one on top of another. Plus, the containers can be loaded onto the aircraft with no net around it, which saves another 1.3 centimetres in height. Alongside the ten lightweight containers, the remaining two units accommodate the big parts, such as the flight case with the spare chassis or the hundred wheel rims.

Each of the 12 units has a unique worldwide number plate and each component packed inside the containers has a QR code, so that by using a scanner everything can be located. This painstaking organisation doesn't just achieve labour and cost efficiency. Customs officers, too, have a need for information. Whether the serial numbers of the 100 radios, the number of chassis components, packets of screws, or rolls of tape – Porsche puts a lot of effort into reliable documentation. Everything imported into the various countries has to be exported out again. The containers are x-rayed, and customs officers may, of course, want to unpack them. Time for this is factored into the schedules.

The two Porsche 919 Hybrids don't fit onto pallets, and instead travel securely strapped down onto extra car racks. All of their fluids have been drained, fragile body parts, such as mirrors and wings, have been packed safely elsewhere. A set of show tyres is fitted.

Between the races some components, for example the gearboxes, go on commercial flights to Germany for revision. Hazardous materials go separately. These include adhesives and resins, as well as spray cans and the lithium-ion batteries for the hybrid drive system. These batteries even require permission from federal aviation administration offices in the various countries. The fact that Porsche possesses considerable expertise in hybrid matters helps the race team, but the procedures are time-consuming nonetheless. The hazardous materials also have to stay in a secure room for 48 hours before and after every flight without being moved.

The team also ships some items by sea, which is considerably less expensive, but also much slower. Equipment shipped in August will only return in January. But then it triples what is needed. Because of the long distances there are three sets of sea freight on the high seas. The contents consist of relatively inexpensive but heavy equipment. Metal posts, for example. Instead of flying 20 of those heavy Tensator barriers around the world, it is cheaper to buy sixty of them and load them onto three vessels. It's all about efficiency.

In focus

Porsche sports car development: Le Mans winning cars

With a total of eighteen overall wins at Le Mans, Porsche holds the unbeaten record for the 24-hour race – and its victories have been won with a wide range of different racing cars, each of which was at the technological cutting edge of its era.

After racking up multiple class victories and many race starts, Porsche first achieved its long-held ambition of being crowned the overall winner at Le Mans in 1970, with the 917 K (for 'Kurzheck' or short tail) Coupé. When the new regulations for the sports car world championship were published at the end of 1967, Porsche decided to design a car for the up to five-litre engine displacement class. At that time, the vehicle was still required to enter small-scale series production for homologation purposes. The 917 was equipped with an air-cooled twelve-cylinder engine; the 4.9-litre version delivered 580 hp (426 kW) at 8,300 rpm. Hans Herrmann (DE) and Richard Attwood (GB) won the 1970 race in the red 917 from Porsche Salzburg. "The circumstances were a little strange," recalls Attwood. Before the race, he voiced two conservative wishes: "Firstly, I wanted the 4.5-litre twelve-cylinder engine instead of the five-litre engine, which I considered too fragile. Secondly, I wanted the short rear end version of the 917, because the long rear end felt unstable." After qualifying, the dejected pair found themselves in fifteenth place, regretting their decision for the safer option. But in the race itself, consistency and reliability won out.

1971 saw a further victory for a 917 Kurzheck – this time with Gijs van Lennep (NL) and Helmut Marko (AT) at the wheel. The pair only found out afterwards that the car was fitted with an ultra-light – but highly controversial – magnesium tube frame. The 800-kilogram 4.9-litre sports car also featured some unusual adjustments for aerodynamics: The "shark fins" on the rear were designed to improve stability and reduce drag by eleven per cent. On their journey to the second Porsche win, van Lennep and Marko broke two records, which would stand for another 39 years – covering a distance of 5,335.16 km (3,315 miles) and achieving an average speed of 222.3 km/h (138 mph). They also won the "Index of Performance" for the lowest fuel consumption in their engine category.

In terms of displacement, the next Porsche winner – the first successful turbo at the Circuit de la Sarthe – was dwarfed by its predecessor. In 1976, the race was won by the 936 Spyder, fitted with a 2.1-litre six-cylinder flat biturbo from the 911 Turbo RSR, delivering 540 hp (397 kW). Aluminium was now available as a light and – compared to magnesium – safe material for the tube frame of the open car. The aerodynamically optimised body was made of plastic; van Lennep and Jacky Ickx (BE) took turns to drive. Ickx achieved his greatest Le Mans victory with the 936 Spyder the

following year: In 1977, after his own 936 broke down, he joined Jürgen Barth (DE) and Hurley Haywood (USA), who had encountered problems of their own and were lagging behind in 42nd place. “What happened next was exhilarating”, says Ickx, even today, so many years after the event. “I drove all night, getting faster and faster, despite the rain and the fog. We got to position 35, 28, 20, nine, six, five – everyone sensed that we might just achieve what had previously been unimaginable. Jürgen and Hurley drove faster than ever, and the mechanics were unbelievable.” In the morning, three Renaults retired from the race – leaving the 936 16 laps ahead. In the last hour, one of the cylinders in the six-cylinder Porsche engine failed. But Barth managed to bring the damaged 936 home to victory.

In 1979, the works team’s 936s were favourites to win, but encountered some obstacles along the way. The fifth overall win for Porsche came in the form of private team Kremer Racing in a 935K3 – a racing version of the 911 with a three-litre, six-cylinder flat engine. This 600-hp (441 kW) variant represented the start of an age in which series-produced racing cars dominated the so-called Group 5 category. Visually, the car had very little in common with the 911 Turbo. The 935 was bulkier, with a flat front and an imposing twin wing on the rear. This 935 was the first car with a water-cooled four-valve cylinder head, which was later put into series production.

By 1981, the old Group 6 prototypes had been readmitted to the race at Le Mans. By this time, the 936 had a larger turbo engine with 2.6-litre displacement; Ickx and Derek Bell (GB) won with a 186-kilometre (115.1-mile) lead.

In 1982, the same drivers achieved the seventh overall race victory for Porsche, this time in a completely new vehicle: The era of group C was under way, and the innovative and uncompromising Porsche 956 had an unbeaten run for many years of the Le Mans race (winning in 1982, 1983, 1984 and 1985). The car – the first Porsche racing car with an aluminium monocoque chassis and ground effect aerodynamics – benefited from a highly efficient six-cylinder flat biturbo. The next incarnation of this futuristic car was the Porsche 962 C, which the works team drove to victory in 1986 and 1987. The group C racers, the 956 and 962, were also the launching pad for a new technical revolution: the Porsche double-clutch transmission. For the first time ever, the Porsche Doppelkupplung (PDK) allowed drivers to change gear without interrupting traction.

When group C came to an end, it was replaced by new prototype classes for which Porsche never developed a works car. But its victories at Le Mans continued to rise: In 1994, a modified Dauer 962 won the new GT1 class. In 1996 and 1997, Joest Racing emerged victorious in the TWR Porsche.

The 911 GT1, developed by Porsche for works and customer use in GT motorsport, made its racing début at Le Mans in 1996. The GT1 class was for closed sports cars based on series-production cars. They could compete with the Class 1 prototypes, some of which were open cockpit in design, for first place on the podium.

The GT1 was the first 911 ever to be fitted with a water-cooled mid-engine, which was combined with a balanced axle weight distribution and aerodynamic improvements. In 1998, Porsche used a carbon-fibre chassis for the first time in the reworked GT1. As a result of its carbon-fibre-reinforced plastic monocoque, a redesigned front suspension and a reduced-weight battery and generator, the GT1 was around 50 kilograms lighter for the 1998 race. The three-plate carbon-fibre race clutch was also new. The six-cylinder flat biturbo engine – carefully tuned to optimise consumption – was by now capable of delivering 550 hp (405 kW).

In 1998, the year of its 50th anniversary, Porsche had yet more reasons to celebrate when two GT1s placed first and second in the race. The winning driver team was comprised of Laurent Aïello (FR), Allan McNish (GB) and Stéphane Ortelli (MC). Porsche fans had many years to savour this success; the company did not enter a works racing car in the top category again until 2014. Though in the hands of the customer motorsport teams, the 911 RSR was a familiar class winner in the GT category throughout. With the futuristic Porsche 919 Hybrid, Porsche raced to its 17th and 18th overall victories in Le Mans in 2015 and 2016.

In focus

Technology transfer in the rear view mirror

Sporting ambition is what has inspired Porsche engineers from the start. The race circuit has been the merciless test platform for sports car technology for seven decades now. Examples of technology transfer include the mid-engine, aerodynamics, turbocharging, PDK, regulated all-wheel drive and hybridisation.

Mid-engine, synchronisation, dual ignition

The Porsche 550 was created for the company's first factory racing programme, and it immediately won the Nürburgring race in 1953. Positioning of the four-cylinder flat engine in front of the rear axle made the Spyder very agile. In 1996, the mid-engine concept was continued in the Boxster. A five-speed transmission with Porsche synchronisation was used in the 550; it is similar to the transmission introduced to 901/911 production cars in 1963. For good measure, two spark plugs were used per combustion chamber in the 550 for optimised combustion – this type of dual ignition was introduced to Porsche production cars in 1988 in the 911 Carrera (type 964).

Trailing edge, duck tail, active aerodynamics

Ferdinand Alexander Porsche sketched the 904 Carrera GTS Coupé of 1963 with a trailing aerodynamic edge at the rear of the car. The first front spoiler was introduced on the 911 S in 1971. It accelerated air flow under the vehicle and diverted a portion of the air to the sides; this reduced lifting force at the front of the car. In 1972, the Carrera RS 2.7, which was designed for motorsport, set new standards: not only was it equipped with a front apron that extended low to the ground; it also had a distinctive spoiler over the engine cover – the legendary "duck tail".

However, the really phenomenal technology platform of the 1970s – in terms of its aerodynamics too – was the Porsche 917. The 12-cylinder race car was built in two versions: one with a short rear section and high downforce for race circuits with lots of corners, and one with a long rear section that was optimised for low air drag intended for high-speed race circuits. To increase downforce in corners, adjustable flaps were added at the rear, which were connected via rods to the wheel suspensions. When the driver steered into a corner, the flap above the unloaded rear wheel on the inside of the corner would be extended to increase wheel load by air pressure, improving stability. The first step had been taken towards active aerodynamics, which Porsche introduced to production cars in 1988 with the automatically extending rear spoiler of the 911 Carrera. On the 911 Turbo presented in 2013, the Porsche Active Aerodynamic (PAA) system

was used to adjust the rear wing and for the first time the front spoiler. The extensive system of adjustable aerodynamic elements in the 918 Spyder represents pure racing technology on the street.

Turbocharging and intercooling

For the American Can-Am series, Porsche further developed the 917 Coupé into the open cockpit Spyder, but the 560 hp output of the 4.5-litre V12 engine was inferior to the 750 hp engine displacement giants of the U.S. competition. Porsche reacted and developed both a 16-cylinder engine and a forced induction system for the 12-cylinder engine. The pressure build-up of the charging air would be regulated to make it suitable for high dynamic load changes and speed changes in the racing engine. The engineers turned away from increasing charge pressure in the induction air, opting instead for the use of turbocharging. Undesirable excess pressure was diverted from the charger via a bypass valve. The 917/10, initially with 850 hp, was the dominating race car of the Can-Am series, and the introduction of turbocharging to Porsche production sports cars became legendary. The 911 Turbo went into production in 1974. Meanwhile, turbocharging technology in the 917/10 went one step further: intercoolers reduced the temperature of the compressed air for better cylinder filling and increased power. The 911 Turbo 3.3 benefited from this technology in 1977.

Porsche double-clutch transmission

Back in 1964, Porsche worked on a power shifting dual-clutch transmission. Four years later, tests were conducted on an automatic four-speed transmission based on the dual-clutch principle, and other designs followed in 1979. Finally, the Porsche Doppelkupplungsgetriebe (PDK) was created in 1981. In 1986, the electronically-controlled power shifting spur gear transmission was tested in the Group C Porsche 956 race car, as well as in production sports cars. The ability to offer shifting without interruption in the flow of power was especially advantageous for turbocharged engines, because the driver was able to continue to push the accelerator pedal during shifting to avoid a drop in boost pressure. Initial tests of the direct shifting transmission were conducted in 1983 in the Group C Porsche 956.003 race car. In 1986, the 962 C PDK won the World Championship race in Monza. Progress in the engineering of the control electronics finally enabled the introduction of the PDK to production cars. In 2008, Porsche introduced PDK in the 911 Carrera.

All-wheel drive control

The 959, developed in 1983 for what was known as Group B at that time, had an advanced all-wheel drive system with variable control of the centre differential lock; it controlled the distribution of torque between the two axles as a function of load and grip values at the wheels. This control strategy proved to be so successful that Porsche developed it further and adapted it for use in the Carrera 4 in 1988. To optimise vehicle dynamics further, the engineers equipped it with a basic torque distribution of 31 to 69 per cent (front to rear axle) via a planetary distribution gear. The system also had a hydraulically activated centre differential lock and transverse differential lock for nearly step-less adjustment of the distribution ratio. Its operation was controlled by electronics that embodied technical know-how from the 959.

Race cars with hybrid drives

In 2010, Porsche nearly achieved a sensational race upset with its 911 GT3 R Hybrid that embodied promising future technology: this GT3 – with a power output of 465 hp from a 4.0-litre, flat 6-cylinder rear engine and two electric motors at the front axle, each producing 75 kW of power – was in the lead until just two hours before the end of the 24-hour race on the Nürburgring. This innovative front wheel drive was also an object of testing: the hybrid concept of the 918 Spyder, which also included an electric motor drive at the front axle, is a direct advanced development of the system used in the 911 GT3 R Hybrid. The highly innovative 919 Hybrid continues to write new chapters in this tale.

In focus

Porsche motorsport innovations for production cars (excerpt)

Technology	First use in a race car		First use in a production car	
Ring synchronisation	**1952**	356	**1952**	356
Dual ignition	**1953**	550	**1955**	356 A 1500 GS Carrera
Five-speed gearbox	**1955**	550 A Spyder	**1963**	901/911
Mid engine	**1955**	550 Spyder	**1963**	904 Carrera GTS
Disc brakes, internally gripping	**1959**	356 B 1600 GS Carrera GT	**1961**	356 B Carrera 2
Multi-joint rear axle	**1961**	718 RS 61 Spyder	**1977**	928
Fuel injection	**1964**	904/8	**1968**	911 E, 911 S
Internally ventilated brake discs	**1965**	Porsche 906-8 Bergspyder	**1966**	911 S
Polymer fuel tank	**1967**	911 R	**1973**	911 E, S, RS, 2,7
Active Aerodynamics	**1969**	917	**1988**	911 Carrera
Disc brakes, perforated and internally vented	**1970**	908/03	**1974**	911 Carrera RS 3.0
ABS	**1968**	908/02	**1983**	928 S
Adjustable stabiliser	**1971**	917	**2007**	Cayenne Turbo (PDCC)
Turbocharging with bypass valve	**1972**	917/10	**1974**	911 Turbo
Four-piston aluminium brake calipers	**1973**	917/30	**1977**	911 Turbo 3.3
Intercooling	**1974**	917/10	**1977**	911 Turbo 3.3
Four-valve cylinder head, water-cooled	**1978**	935-78	**1985**	928 S
Tyre pressure monitoring (TPM)	**1980**	924 GTP Le Mans	**1988**	928 S4

Technology	First use in a race car		First use in a production car	
Aluminium monocoque	**1981**	956	**2011**	911 Carrera (Mischbauweise)
Monoblock aluminium brake caliper	**1982**	956	**1996**	Boxster
Motronic	**1982**	956	**1983**	911 Carrera 3.2
Porsche-Doppelkupplungs-getriebe (PDK)	**1984**	956	**2008**	911 Carrera
All-wheel drive control	**1983**	959	**1988**	911 Carrera 4
Damping and levelling control	**1983**	959	**2005**	911 Carrera S
Titanium connecting rods	**1983**	959	**1983**	911 Carrera
Metal catalytic converter	**1990**	944 Turbo Cup	**1990**	911 Turbo
Ceramic brakes	**1991**	962	**2001**	911 Turbo S
Carbon fibre monocoque	**1998**	911 GT1	**2003**	Carrera GT
Hybrid drive with e-motor on front axle	**2010**	911 GT3	**2013**	918 Spyder

In focus

Neel Jani on his record-breaking lap at Le Mans

On 10 June 2015, Neel Jani set a new qualifying record at Le Mans, completing his lap of the track in 3:16.887 minutes at an average speed of 249.2 km/h (154.8 mph).

"It was just after 10 pm on Wednesday, still not quite dark and it was the first lap of qualifying. I knew that I would probably have just this one chance for pole. The weather forecast was uncertain and Porsche is happy if any team colleague gets into pole position. I cautiously ran in the tyres on the warm-up lap and brought them up to temperature. When I was driving towards the start:finish line, I saw it – a slower LMP2 car. I wanted to overtake it at the start of the Mulsanne straight. But in the Tertre Rouge, I realised that it wasn't going to work. The LMP2 was too far away. I would meet it in the first chicane and lose time. To prevent this, I boosted more than is healthy, because you miss the electrical energy later on. I just managed to pass the LMP2 before I had to start saving fuel. Through the chicane and then I accelerated out of it. Although I now had less boost, I had made up some time. In the second chicane, I had to slow down somewhat earlier in order to save the fuel that I had burnt up previously. As I was driving slower, I braked too early. Then comes Mulsanne, with its bumps in the road. This time I hit the curve perfectly and also the kerb coming out of the bend, without going into the rev limiter. Then over the crest towards Indianapolis. A Corvette came into view in front of me. Indianapolis is a fast right-left combination. I thought that if I took the right-hander with a lot of speed, I would in fact come out too far on the left, but then I would simply stay on the left and push in on the inside next to the Corvette. I flashed my headlights to warn him and drove in uncompromisingly on the left onto the dirty track. I knew the Corvette had a camera pointing to the rear and would have an arrow showing from which side a car was attacking. So then I thought, if this was going to work at all, then it would be with a Corvette. In any case, they're all professionals on the track in Le Mans. I was able to press myself into the steeply banked curve. Done it! Now Arnage, an extremely slow right-hander. Just like Mulsanne, it has an uneven surface in the braking zone. This time it was spot on. I accelerated towards the Porsche curves. At this point, you can see a good ten seconds ahead. There was no longer a car! My time had come.

At the limit through the Porsche curves, steering into the right-hander, in sixth gear. The first left-hander, the second – I gave it full throttle the whole time. You wouldn't do that normally. Nothing had better go wrong in the Porsche curves, otherwise there'd be a dreadful crash. Yet in this qualifier, I risked a bit more for a few tenths of a second. So first the second left-hander, then the long right-hander. Don't slide out too far when changing direction because there's only grip on the inside. And it actually worked as well. Then comes Karting, a left-hander that slopes to the outside. The car always understeers there, you really have to make sure that you stay inside the white line. I was now four seconds faster than the reference. Two more chicanes. Lots of people drive straight on there because they have problems adjusting after the ultra-fast Porsche curves. At the Ford chicane, the entrance isn't visible, and it's even more difficult in the dark. But I had noted the braking point. Avoid the artificial grass at the exit to the last chicane, otherwise you have no traction to accelerate. Full throttle. Finishing line. I was thinking about the LMP2, about boosting too early and the Corvette... Then I saw the 3:16.887. And I was glad I wouldn't have to go through all that again."

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