Track stars

Ahead of the start of the electric racing series' third year, several Formula E engineers gave *ATTI* a rare glimpse into the rigors of pre-season testing and development

WORDS BY LEM BINGLEY

The testing and development period for Formula E is intense. With only two official pre-season test sessions before qualifying, there is little room for error



When the latest Formula E championship began in October, it marked the culmination of three years of preparation. The electric racing series may have reached its third season, but this year's opening race in Hong Kong was arguably the first opportunity for the teams to really enter into their stride.

In Formula E's maiden season, from September 2014 to June 2015, all of the teams used identical machinery. Then, in the second season, when the teams were allowed to create their own powertrains for the first time, they had a very tight timeline.

"The decision to open powertrain competition was made very late in 2014," recalls Vincent Gaillardot, project leader of the Renault e.Dams team. "We had six months to develop a full electrical powertrain. That was very, very challenging, so I think we all arrived at the Donington test in July 2015 with very little experience."

Despite the constraints, Renault went on to win the championship for a second time. Now Gaillardot is focused on competing for a third title with "a much more comfortable schedule". Comfort is relative, of course. There is still enormous pressure to get the cars right first time. Unlike Formula 1, Formula E rules out almost all mid-season development. While suspension is set up for each track, other hardware is fixed for the whole season – the FIA will permit changes only to correct demonstrable reliability problems. Software, however, can be freely rewritten. "The control of your motor is the one area where you can play during the season," says Gaillardot.

HELPING HANDS

Formula E's constraints are designed to curtail costs, but they place a heavy burden on pre-season development and testing. This work is tackled by Formula E constructors, which can be distinct from the racing teams, as Thomas Chevaucher, technical manager for DS Performance, explains: "All of our development is done by DS Performance, which is part of the PSA Motorsport division. And then our partner, Virgin Racing, is in charge of the race cars."

While a race team may have 15 people running four cars – two per driver – the factory side tends to be leaner. "We have only five or six people involved in Formula E," says Chevaucher. "It's not small – just a little bit smaller than a World Rally Championship (WRC) team. But we have all the motorsport division behind us."

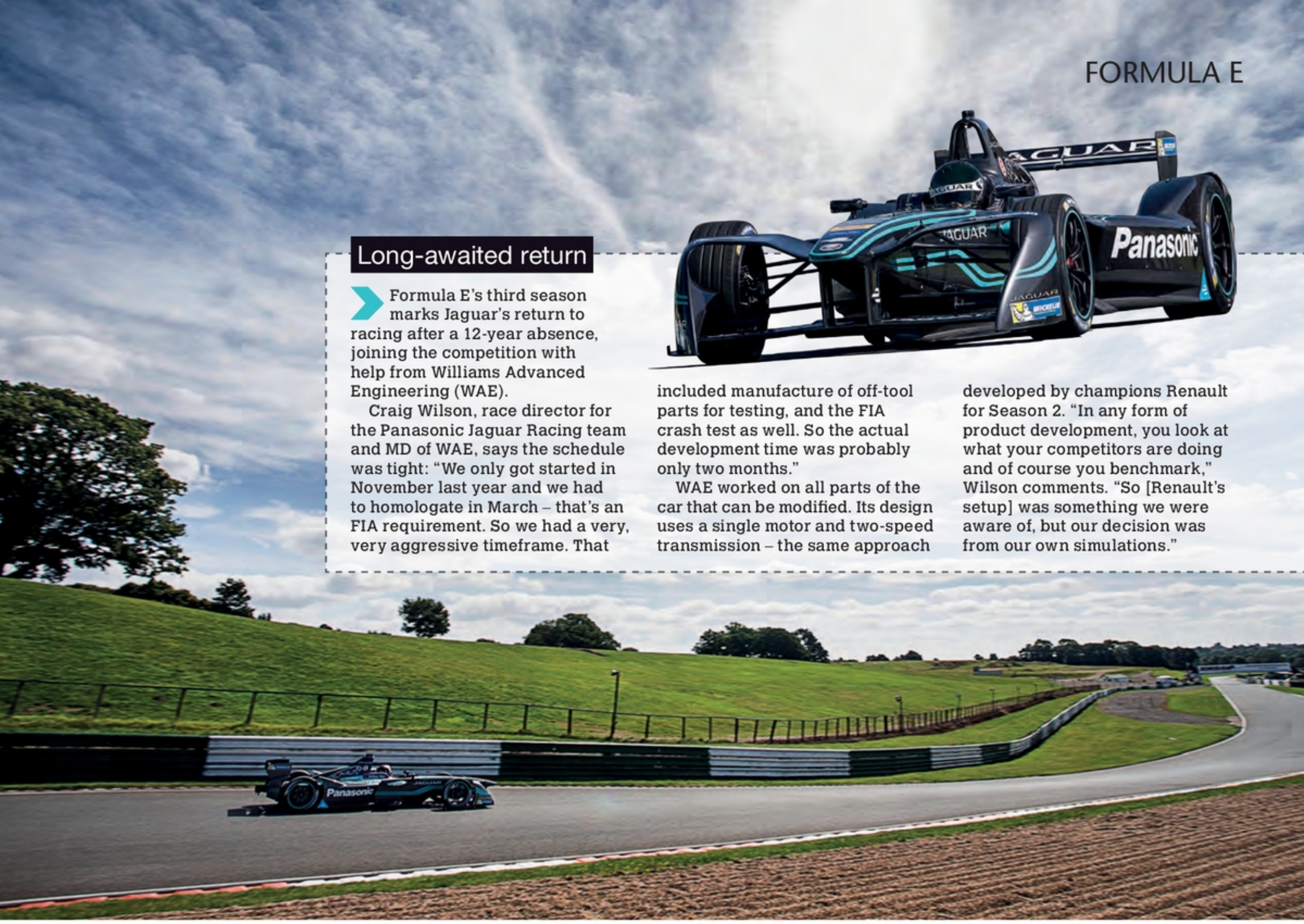
Split into six sessions over three days, pre-season testing typically involves a rigorous program consisting of long runs, qualifying simulations, race setup evaluation as well as a parts shakedown

Alain Prost and Jean-Paul Driot, who joined forces to create the Renault e.Dams Formula E team

Renault e.Dams driver Nico Prost finished fourth at the first race of this season in Hong Kong in October, while teammate Sébastien Buemi took pole







According to Jaguar, Formula E will provide a welcome proving ground for developing future electric road vehicle technology

Long-awaited return

Formula E's third season marks Jaguar's return to racing after a 12-year absence, joining the competition with help from Williams Advanced Engineering (WAE).

Craig Wilson, race director for the Panasonic Jaguar Racing team and MD of WAE, says the schedule was tight: "We only got started in November last year and we had to homologate in March – that's an FIA requirement. So we had a very, very aggressive timeframe. That included manufacture of off-tool parts for testing, and the FIA crash test as well. So the actual development time was probably only two months."

WAE worked on all parts of the car that can be modified. Its design uses a single motor and two-speed transmission – the same approach developed by champions Renault for Season 2. "In any form of product development, you look at what your competitors are doing and of course you benchmark," Wilson comments. "So [Renault's setup] was something we were aware of, but our decision was from our own simulations."

Arrangements at Renault are similar, Gaillardot says. Fewer than 10 people develop the Renault car, but they can call on the expertise of Renault's motorsport unit, including the Renault F1 team. However, not every constructor has the luxury of a large motorsport division behind it.

"This is our first single-seater championship," says Vinit Patel, chief engineer at Mahindra Racing. "I don't doubt that the likes of Renault and DS have an edge but it's my job and that of my colleagues at Mahindra to prove ourselves, and get the investment required to try to match or beat their facilities in the long run."

Patel says Mahindra also aims to "catch up through its partnership with Magneti Marelli", the Italian electronics company that has a long motorsport history of almost a century.

GAME CHANGERS

As Chevaucher points out, big teams aren't required in Formula E because constructors don't build an entire car. Everyone still uses a standardized chassis, tire, aerodynamic package, front suspension and battery. The teams design and build their own motor, transmission and rear suspension.

"The heavier the powertrain is, the easier it is to make it energy efficient, but if the car is too heavy you will lose performance," Chevaucher notes. "This is what makes the difference between competitors."

Constructors are limited to 15 days of track development, between January 1 and July 31. The cars are then handed over to the teams for track testing ahead of the opening round. Constructors allot their 15 days as required.

"You are completely free [to do what you like], although whether you test for one hour or nine hours, it counts as one full day," says Gaillardot. However, simulation or static tests – including an entire car on a dyno – aren't counted. As a result, this is where the bulk of development is carried out.

Work starts with establishing the basic design approach and component sizing. "You have to identify the most beneficial first-order parameters for your performance, by raw analysis and by doing a lot of simulation," says Gaillardot. Development then moves

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>
> Vinit Patel, chief engineer, Mahindra Racing

Get a grip

Manufacturers are often keen to make the link between racing and the road, and the connection is particularly clear for Michelin, sole supplier of tires to Formula E. The tires used are all treaded rather than slick and come in road-ready sizes: 255/40R18 at the front and 305/30R18 at the rear.

Using one all-weather tire fits Formula E's sustainability vision. With no need for slicks, intermediates and wets, Michelin ships far fewer tires to each race than for other single-seater series. Each driver is allowed only one set per race, plus two spares.

Seasons 1 and 2 used the same tires, but a new version was then developed for season 3. "The teams asked us not to increase the grip," says Serge Grisin, motorsport director at Michelin. Instead the Pilot Sport EV2 is more efficient.



"Rolling resistance is more than 10% better and the weight saving is around 1kg for a set of four," he says. "It's probably the most efficient racing tire in the world."

The new tire was released to the teams in May, along with data for their simulations, while Michelin has done extensive track testing. "We're neutral so don't want to work with one team and not the others, so we are doing our own development with our own Formula E car," Grisin says.

Through its involvement in the electric racing series, Michelin is able to improve not only its technologies, but also its simulation tools and its test methodologies and techniques

into its physical phase: "We have the capability of component testing in isolation and full powertrain dyno capability, with dynamic behavior. We can do a replay of a lap or test some endurance-specific scenario." Some of this equipment is shared within Renault: "We do benefit from the infrastructure we have in place for F1," Gaillardot admits.

KNOWN QUANTITIES

Like most motorsport teams, Renault is cagey about its precise procedures and is unwilling to name which testing suppliers it works with. That being said, the battery is a known quantity. All teams use the same liquid-cooled, lithium-ion package designed and built by WAE. Little has changed since Season 1, with the energy-storage system providing up to 28kWh per race. Peak output of 200kW is available during testing, qualifying and for fleeting periods during the race via the unique Fanboost facility. Normal race output is capped at 170kW, up from 150kW in Season 1.

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The battery case is a structural chassis member, crash tested as part of the car. That's one reason why drivers change cars rather than swap batteries half way through each race. And with a capped battery, power at the wheel depends on powertrain efficiency. The short development window for Season 2 led to a wide variety of solutions. Both NextEV and DS Virgin Racing used twin electric motors with fixed output ratios. Torque vectoring is outlawed, so the twin motor design was chosen for packaging or efficiency reasons.

All the other teams used a single motor plus gearbox. Championship winner Renault used two gears; runner-up ABT Schaeffler Audi Sport used three; Dragon, Venturi, Trulli and Mahindra Racing chose four; while Aguri and Andretti stuck with the five-gear drivetrain from Season 1.

Diversity has continued in Season 3. "There's still variation up and down the grid, with twin motors, single motors, more ratios, fewer ratios," says Patel. "It's a great formula for engineers – like motor racing in the heyday of the 1960s and 1970s, when solutions to problems in F1 were very different. Today, F1 quite quickly converges on a single solution."

More technological variety is likely to be injected into Season 5 of the championship, which will see a new chassis and improved battery, thus ending the need for car swapping. Beyond that, perhaps from Season 7, constructors expect to be able to build their own batteries – a challenge that is under investigation already. As Gaillardot says, "The fact that we are free to perform any development at the factory, on any rig or calculation, gives us the flexibility we need to work way ahead." ‹