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McLaren MP4-12C, Lexus LFA, Lamborghini Aventador LP700-4 and Bugatti Veyron 16.4 Grand Sport

From our July, 2012 issue / By Eric Tingwall / Photos by Andrew Yeadon

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That massive hunk of steel in your driveway is slowly corroding into obsolescence -- both figuratively and literally. About the time that rust finally eats through the floorboards of your shiny new 2012 model, you'll be able to purchase -- no, afford -- a plastic car.

Set aside any preconceptions of Happy Meal toys, sporks, or Saturns, because this isn't your typical plastic. The cars of the future will be made of carbon-fiber-reinforced plastic, a material that is stronger than the metals it replaces. Carbon fiber is durable enough to be used for the entire structure of the car -- not just the body panels -- and it is lighter than steel and aluminum, allowing automakers to build more efficient and better-performing vehicles. Also, it doesn't corrode.

McLaren delivered the first carbon-fiber production car twenty years ago with the three-seat, million-dollar F1. That car was followed by equally extreme exotics like the Ferrari Enzo and the Mercedes-Benz SLR McLaren, but carbon fiber won't be exclusive to six- and seven-figure supercars much longer. Innovation, investment, and expansion in the composites industry have pushed down manufacturing time and cost while increasing availability. Outside the auto industry, the high-strength composite is now used in Boeing's 787 airplane, NHL hockey sticks, and even bicycles for the recreational rider. The price of entry for a carbon-fiber car is about to plummet. In 2013, BMW intends to introduce the electric i3, which mounts a carbon-fiber passenger cell on top of an aluminum frame and should sell for less than \$50,000.

Of the 271 cars on sale in America today, only the Bugatti Veyron, the Lamborghini Aventador, the [Lexus LFA](#), and the McLaren MP4-12C boast carbon-fiber tubs. This elite group, which totals 2836 hp and \$2.9 million, is at the peak of automotive technology, yet it also represents the imminent democratization of carbon fiber. Even among these cars -- the most exotic, most expensive in the industry -- there is a variety of construction techniques and a \$1.7 million price spread. At this pivotal moment for composite vehicles, these four cars are leading the change.

McLaren MP4-12C: The Start of Something Great.

There was never any question that McLaren's return to road-car production would include a carbon-fiber chassis. The folks in Woking simply don't know anything else. Every car they've built in the past thirty-one years, whether for the road or the racetrack, has carbon fiber at its core.

McLaren introduced the automotive industry to the high-strength composite with Formula 1's first carbon-fiber monocoque in 1981. Building the MP4/1 racing car, though, required more composites expertise than any motorsports outfit possessed, so production was outsourced to Hercules Aerospace. Eleven years after the MP4/1, McLaren was first with carbon fiber again -- this time with a production car designed around a list of superlatives: the highest power-to-weight ratio, the best-handling supercar, and the fastest production car in the world. Achievement was accompanied by progress: McLaren by then had its own composites facility where the handmade F1 chassis was constructed.



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McLaren's carbon-fiber mastery is readily apparent in the new MP4-12C. While the two cars were built for different times, different prices, and different purposes, the contrast between the F1 and the MP4-12C highlights how far carbon-fiber technology has advanced. Piecing together the F1's composite chassis back in the 1990s took 3500 hours; today, manufacturing the MP4-12C's tub requires just four hours. McLaren can move that quickly because it is the only automaker to manufacture the monocoque as one piece. Every other company is essentially gluing its cars together like Tamiya models. This technique gives McLaren the ability to produce 4000 MP4-12Cs every year, whereas Lamborghini will build about that many Aventadors over the car's entire lifetime.

At 3210 pounds, the MP4-12C is the lightest car in this supergroup by a 350-pound margin. That fact is made clear by just how eager it is to change directions compared with its composite brethren. While the other cars here need to be coaxed through turns, flicking the McLaren around feels like intuition. Swapping antiroll bars for a sophisticated active hydraulic system that links all four dampers has created supernatural handling abilities. The MP4-12C rides like a Mercedes-Benz S-class on the straights yet swings through corners with more body control than a Pilates instructor.

The twin-turbo V-8 packs a 592-hp wallop that is much larger than its 3.8-liter displacement would suggest. Although it's perfectly adept at metering out power, it has neither the high-strung emotion of a normally aspirated eight-cylinder nor the sonorous smoothness of a V-12. Upshifts from the seven-speed dual-clutch automatic are satisfyingly quick, which highlights how not quick multiple-gear downshifts can be. And of all the supercar quirks you'll find in this quartet, none is as aggravating as trying to convince the McLaren's touch-sensitive door handle that you should be allowed inside.

For a company with so little production-car experience, it is astonishing that McLaren has built a car this good. And if the MP4-12C is any indication, there are even more good things to come from Woking as it develops an expanded lineup to challenge Ferrari. One editor postured that the MP4-12C is the car that Lotus should be building. With Lotus's future uncertain, you could also turn it around and say that McLaren is the new Lotus. With its sharp technical focus, aversion to weight, and divine dynamics, the MP4-12C delivers a driving experience that few can replicate.

Like concrete, but not quite so heavy

Just as thousands of metals can claim to be steel, carbon-fiber-reinforced plastic (CFRP) is a term with broad meaning. The defining characteristic, though, is fairly basic: strong, slender fibers of carbon are enveloped in a resin that is cured to become a rigid part. The fundamental mechanics of CFRP are similar to steel reinforcement rods placed in concrete. While the resin is responsible for the solidity of the part, the carbon fibers add critical strength. A CFRP part typically weighs 50 to 70 percent less than a steel part that can withstand the same forces, but carbon fiber doesn't have the elasticity of the metals it replaces. That means the material cracks, rather than bends, when it fails. For that reason, many of today's carbon-fiber cars use aluminum crash structures in the front and rear to dissipate energy in the event of a collision.

McLaren MP4-12C

BASE PRICE \$231,400

POWERTRAIN

ENGINE 32-valve DOHC twin-turbo V-8

DISPLACEMENT 3.8 liters (232 cu in)

POWER 592 hp @ 7000 rpm

TORQUE 443 lb-ft @ 3000 rpm

TRANSMISSION 7-speed automatic

DRIVE Rear-wheel

CHASSIS

STEERING Electrohydraulically assisted

SUSPENSION, FRONT Control arms, coil springs

SUSPENSION, REAR Control arms, coil springs

BRAKES Vented discs, ABS

TIRES Pirelli PZero

TIRE SIZE F, R 235/35YR-19, 305/30YR-20

MEASUREMENTS

L x W x H 177.5 x 75.1 x 47.2 in

WHEELBASE 105.1 in

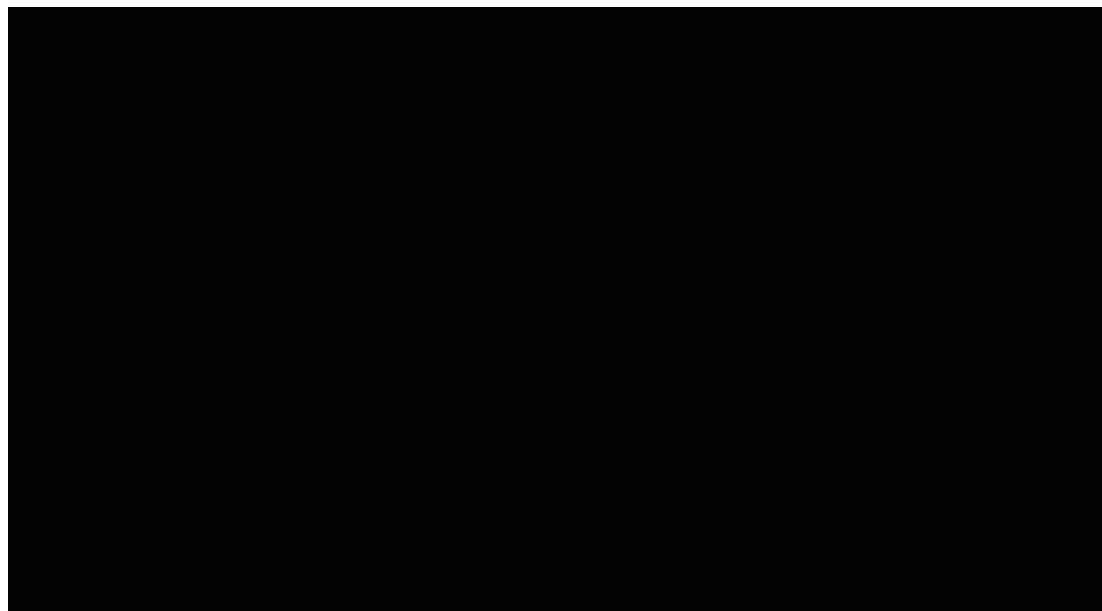
TRACK F/R 65.2/62.3 in

WEIGHT 3210 lb

WEIGHT DIST. F/R 42/58%

EPA MILEAGE 15/22 mpg

0-60 MPH 3.5 sec
TOP SPEED 205 mph



Lexus LFA: 121 Years in the Making.

Trace the lineage of Toyota CEO Akio Toyoda and you'll eventually arrive at Sakichi Toyoda, the man who started Toyota Loom Works long before Toyota Motor Corporation existed. Sakichi, who was raised in a textile-manufacturing region and was inspired by Japan's late-nineteenth-century patent law, invented the automatic loom and fueled Japan's industrial revolution with an unrelenting stream of textile innovations. That explains why 121 years after Sakichi received his first patent, Toyota is the only automaker to weave its own carbon fiber.

At LFA Works in Motomachi, Japan, the mesmerizing circular loom that braids the car's hollow, carbon-fiber roof rails is more than a slight nod to the company's past. It reflects Sakichi Toyoda's concept of *jidoka*, or automation with a human touch. In the 1920s, *jidoka* meant that an automatic loom could detect a thread breakage and stop weaving. That same concept -- although a photo-optical system now detects broken fibers -- led to one of the significant patents that made Lexus's carbon-fiber braider a reality.



When development of the LFA began in 2000, Toyota had no intention of building a carbon-fiber car, let alone a Lexus. Instead, the Japanese giant was pursuing an aluminum-spaceframe sports car with a Toyota badge. As performance and refinement expectations simultaneously increased, though, engineers became convinced that carbon-fiber construction was a necessity. The switch resulted in a car that is 220 pounds lighter and four times stiffer than the original concept.

Open the door of an LFA, and you'll find a strip of exposed carbon fiber just behind the intersection of the A-pillar, the dash panel, and the doorsill, where the composite structure experiences some of its highest forces. There are eleven layers of carbon fiber at its thickest point, so rapping your knuckles against it has the feel and sound of punching a cinder block.

Punching the throttle, on the other hand, is far more gratifying. What the 552-hp V-10 gives up in torque is masked by a voracious desire to rev past 9000 rpm, and the high-pitched shriek that accompanies every full-throttle tear is the most righteous noise you've ever heard outside of a racetrack. The six-speed automated manual transmission is averse to automatic mode, and part-throttle shifts work best when you lift your right foot. Low-speed creep and redline upshifts are more civilized than the Aventador's, but the stiff-legged suspension is only moderately more livable. And the LFA's cabin looks like the biggest afterthought in this group. It has the look of a supercar from the prior decade and is rife with ergonomic curiosities that you'd think would be elementary for a company that rewrote luxury with the LS400 and sold nearly 200,000 passenger cars in the United States last year.

Not that we'd let that overshadow the awesomeness of this car's existence. The LFA is a distillation of Toyota's Formula 1 experience into a passionate road car. Perhaps even more exciting is how the company will use its experience with the LFA to produce the next generation of Toyota street cars. The LFA's 500-car production run ends this December, and you can

bet that Toyota won't keep that carbon-fiber loom idle for long.

From defense to driveway

The majority of early carbon-fiber development originated in the defense industry, primarily for naval and aerospace applications. Although fiber-reinforced plastics were commercialized in the 1930s and '40s, using carbon fiber wasn't practical until 1963, when researchers at the British Royal Aircraft Establishment discovered a method for producing reliable, high-strength filaments. The collapse of the Soviet Union and the end of the Cold War in the early '90s sapped the defense industry's demand for carbon fiber, and falling prices opened the door for carbon fiber use in the commercial aerospace, sporting goods, and automotive industries. Today, the market benefits from a diversity of materials and manufacturing methods. While aerospace-grade carbon fiber can cost as much as \$200 per pound, automotive use has been driven by the rise of larger fibers with a price of about \$10 per pound.

Lexus LFA

BASE PRICE \$381,100

POWERTRAIN

ENGINE 40-valve DOHC V-10

DISPLACEMENT 4.8 liters (293 cu in)

POWER 552 hp @ 8700 rpm

TORQUE 354 lb-ft @ 6800 rpm

TRANSMISSION 6-speed automatic

DRIVE Rear-wheel

CHASSIS

STEERING Electrically assisted

SUSPENSION, FRONT Control arms, coil springs

SUSPENSION, REAR Multilink, coil springs

BRAKES Carbon-ceramic vented discs, ABS

TIRES Bridgestone Potenza RE050A

TIRE SIZE F, R 265/35YR-20, 305/30YR-20

MEASUREMENTS

L x W x H 177.0 x 74.6 x 48.0 in

WHEELBASE 102.6 in

TRACK F/R 62.2/61.8 in

WEIGHT 3460 lb

WEIGHT DIST. F/R 48/52%

EPA MILEAGE 11/16 mpg

0-60 MPH 4.2 sec

TOP SPEED 202 mph

Lamborghini Aventador LP700-4: The Opinionated Supercar.

Of all the things that Lamborghini has been over the decades -- beautiful, outrageous, bankrupt -- it's not often been a technical pioneer. But there's no question that the Aventador places Lamborghini in the front pack of automakers with carbon-fiber proficiency. The Italians have a fertile carbon-fiber partnership with the University of Washington (which, in turn, has a similar association with Boeing) and are likely to profit even further from Volkswagen's composite development work now blooming in Qatar. Not that they're struggling to keep up.

Just how carbon-fiber-intensive is the Aventador? Even the molds that create the composite tub are made of carbon fiber. Compared with the usual steel or aluminum forms, carbon-fiber tooling is lighter and thus easier to maneuver in a facility where space is at a premium, like you'll find in a small shop in Sant'Agata Bolognese. For limited-production vehicles, these molds are also a cheaper investment than traditional forms, but the trade-off is a shorter usable life. Lamborghini says the Aventador's forms will last for an average of about 400 cars and that it has only eight molds for Aventador tubs.



With exclusivity guaranteed, Lamborghini cranked up the Aventador's desirability even further by doubling the dose of steroids. How it looks, how it sounds, how it drives -- you cannot ignore it. The Aventador is like a hyperactive ten-year-old without his Ritalin. Launch control is so violent that it can cause the driver to repeatedly activate the right turn signal with a

knee. In Corsa mode, upshifts at redline feel like a sledgehammer whacking the bucket seats. Stiff springs and microscopic amounts of wheel travel mean that the body is always fidgeting over pavement imperfections. Any drive of more than an hour will leave the frazzled driver reaching for another popular drug -- Valium. These are either complaints or compliments. You decide.

By the numbers, there's no mistaking the Aventador for anything but a supercar. At 4070 pounds (600 pounds heavier than Lamborghini's claimed dry weight), it's not a featherweight, but like the Veyron, the Aventador has a huge powertrain and four-wheel drive. It accelerates much like the Bugatti, too, with just enough torque to slip all four wheels at launch but the grip to reach triple-digit speeds in the time that a quick sport [sedan](#) hits 60 mph. Stay committed, and the 6.5-liter normally aspirated V-12 will push the Aventador all the way to a 217-mph top speed. Just as brazen is the fact that Lamborghini intentionally passed on a dual-clutch automatic transmission, claiming that the single-clutch alternative was a better fit for the Lamborghini character. The bucking forward progress that comes at part throttle in first gear? That's taking the bull theme too far.

If nothing else, the Aventador is affirmation that progress doesn't have to mean abandoning the past. Even if Lamborghini has built the most technologically advanced bull in the history of the company, this car comes from the same bloodlines as the Countach and the Diablo -- cars that will grab your attention, lure you closer, and then scare the bejeezus out of you. The Aventador is wildly successful doing each of those, whether you like it or not.

Stronger than steel

Carbon fibers are produced by exposing a carbon-rich precursor material to progressively higher temperatures topping out between 1000°C and 3000°C in an oxygen-free environment. The resulting filament is roughly one-tenth the diameter of a human hair and is almost entirely carbon. The strength of these filaments is what makes carbon fiber as much as ten times stronger than high-strength steel. A single fiber -- called a "tow" in the industry -- is made up of thousands of filaments bundled (but typically not twisted) together.

Lamborghini Aventador LP700-4

BASE PRICE \$393,695

POWERTRAIN

ENGINE 48-valve DOHC V-12

DISPLACEMENT 6.5 liters (397 cu in)

POWER 691 hp @ 8250 rpm

TORQUE 509 lb-ft @ 5500 rpm

TRANSMISSION 7-speed automatic

DRIVE 4-wheel

CHASSIS

STEERING Electrohydraulically assisted

SUSPENSION, FRONT Control arms, coil springs

SUSPENSION, REAR Control arms, coil springs

BRAKES Carbon-ceramic vented discs, ABS

TIRES Pirelli PZero Corsa

TIRE SIZE F, R 255/35YR-19, 335/30YR-20

MEASUREMENTS

L x W x H 188.2 x 79.9 x 44.7 in

WHEELBASE 106.3 in

TRACK F/R 67.7/66.9 in

WEIGHT 4070 lb

WEIGHT DIST. F/R 45/55%

EPA MILEAGE 11/17 mpg

0-60 MPH 3.0 sec

TOP SPEED 217 mph

Bugatti Veyron 16.4 Grand Sport: A Singular Experience.

There's no shortage of facts and figures to describe this car, but it's the price that best explains the Bugatti Veyron. Even with a sticker well in excess of \$1 million, Volkswagen loses money on each car. Why? Well, everything is bespoke, not to mention that the Veyron was designed well before the carbon-fiber advancements now being exploited by Lexus, Lamborghini, and McLaren to build composite cars at a fraction of the Bugatti's price. Not that it matters. Even if there are quicker, less expensive methods for making the monocoque, Bugatti wouldn't have them. In addition to its physical feats, the Veyron's seven-figure price is held up by the craft and tradition of a handmade car. So, just as producing carbon fiber is a labor-intensive process, the bolts in the Veyron must be hand-turned in Molsheim, France. It all pays off -- at least from the Volkswagen Group's perspective -- because the Veyron parlays technical achievement into a marketing message louder than a Formula 1 effort -- and for less money.



The Veyron's engine runs too hot to be covered by a plate of glass. That's just as well, because it's too beautiful to be obscured. Every piece of this car is a work of art. The intake manifolds are held in place by sixteen bolts, each one with a stylized EB embossed in the head. The symmetrical polished filler caps -- one for gasoline and the other for 16.9 quarts of oil -- are jewelry on the rear flanks. You'll be hard-pressed to find more than five pieces of plastic in the leather-and-aluminum-filled cabin.

The Grand Sport's contribution to 1001-hp motoring isn't just the transparent, removable hard top. Take notice of the two football-sized snorkels right above the driver's and passenger's heads, which punctuate the flat-out acceleration experience when the roof is removed. The Veyron clears its throat with a snort followed by the breathy buildup of a 747 taking off a few inches from your skull and the snare-drum patter of sixteen cylinders firing. At first you think the Veyron might suck the cochlea out of your ear before you realize that what the Bugatti really wants is to separate your head from your spine.

Say you motor up to 20 mph with the transmission in automatic mode before flattening the gas pedal. The blue beast contemplates downshifting from second to first all while the four turbochargers furiously, and very audibly, spool up behind your head. The awkward pause leaves enough time to wonder "where's the power?" But this is the wrong question. The calm before the storm is better spent preparing yourself. When the seven-speed dual-clutch automatic eventually finds first, the horsepower gauge on the instrument cluster rips from 60 hp to some 800 hp, at which point looking at the horsepower gauge becomes patently suicidal. Whatever was ahead of you -- no matter how far away -- is now in the rearview mirror.

Just as mind-blowing is the fact that the Veyron drives with all the drama of an Audi A8 when you're loafing down the road. The rock-hard, tailored Michelins thump loudly on the pavement but make only a minimal impact on ride quality. It is this dichotomy -- that a car so capable of face-melting performance can also be so luxurious -- that defines the Veyron. There will be faster and more expensive cars someday, but there will never be another car like this.

Turning fabric into plastic

Tows are bundled, woven, or braided into tapes, sheets, or three-dimensional forms before the resin is cured to create a rigid piece. With prepreg construction, tows are coated in resin before they are arranged into the final shape. In other methods, the resin is pressed into dry carbon-fiber pieces. Both approaches require pressure to evenly distribute the resin and heat to cure it. Because CFRP parts derive so much of their strength from the fibers themselves, the tows are typically aligned in the direction of the highest forces. For parts that are subject to high stresses in multiple axes, several layers may be stitched or laminated together with the fibers oriented in various directions.

Bugatti Veyron 16.4 Grand Sport

BASE PRICE \$1,900,000 (est.)

POWERTRAIN

ENGINE 64-valve DOHC quad-turbo W-16

DISPLACEMENT 8.0 liters (488 cu in)

POWER 1001 hp @ 6000 rpm

TORQUE 922 lb-ft @ 2200 rpm

TRANSMISSION 7-speed automatic

DRIVE 4-wheel

CHASSIS

STEERING Hydraulically assisted

SUSPENSION, FRONT Control arms, coil springs

SUSPENSION, REAR Control arms, coil springs

BRAKES Carbon-ceramic vented discs, ABS

TIRES Michelin Pilot Sport PAX

TIRE SIZE F, R 265-680/YR-500, 365-710/YR-540

MEASUREMENTS

L x W x H 175.7 x 78.7 x 47.4 in

WHEELBASE 106.7 in

TRACK F/R 67.5/63.7 in

WEIGHT 4530 lb*

WEIGHT DIST. F/R 44/56%*

EPA mileage 8/15 mpg

0-60 MPH 2.9 sec*

TOP SPEED 253 mph

*Veyron 16.4 coupe figures

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3 Comments

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sschewe
 Commented on 17/05/12
 at: 9:03 PM

I also remain a tad skeptical.

I am an Audi Quattro aficionado, and Audi has certainly built a lot of A8s and R8s, but I hear that body repairs are expensive and must be done at special places.

Carbon fiber??? I think NOT for street cars---as it's even worse than aluminum.

BTW---we're leasing a Subie Impreza with four doors, room for four real sized people and AWD for the snowy MI where I live. It weighs 3050 pounds! It is composed of rally proven, tough, high strength steel---not even exotic aluminum is required.

andyoo
 Commented on 17/05/12
 at: 1:47 PM

Disagree with this article. I have carbon fiber wheels and frame on my bike. When it crashes and have any crack or damage, the frame/wheel has to be replaced. There is no fixing on carbon. For exotic car, the owner can afford a replacement. For regular joe, it's too expensive to replace a car just because there is a small damage to one part of the car. Like a fender bender will probably make your car unsafe if it's carbon. Plus it's hard to find damage since the crack could be under the clear coat, making it structurally unsafe.

Alleycat10
 Commented on 17/05/12
 at: 1:47 PM

I can see it already. Plastic burns quite well. Regardless of the added plastic, fasteners will be of steel that corrodes. Many a mechanic gets out the torch to cut or heat stubborn corroded fasteners to make repairs or do replacements. Play that torch on or near plastic components and burn they will, and quite rapidly at that, quickly making a pile of ash, hot steel parts and melted/warped aluminum wheels behind.

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