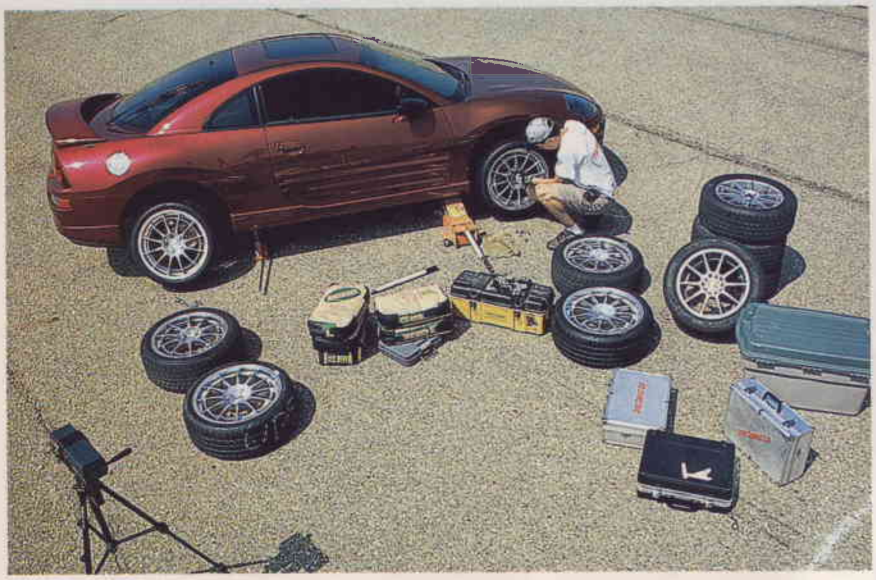
WHICH MATTERS MOST?

by Josh Jacquot and Dave Coleman PHOTOGRAPHY: JOSH JACQUOT

WE USE UP 12 WHEELS AND TIRES, THREE CARS, TWO RACETRACKS, ONE RADAR GUN AND A LAP TIMER SEARCHING FOR THE ANSWER

We're a curious bunch at *Sport Compact Car*. We've always got questions about performance and what we can do to make our cars faster. And, the one question that seems to come up more than any other involves weight. Not just weight—raw ballast, that is—but also rotating weight in the form of larger wheels and tires. This month, we're addressing the weight issue on several levels.



When we first sprouted the idea for this test, it was relatively simple: Find a car and driver that could produce consistent lap times at a road course and then add or subtract weight from the car without telling the driver what changes were made. Record the lap times and see what happens. Simple.

Nothing is ever that easy around here. We soon realized that in the real world, there are hundreds of other decisions facing anyone interested in performance. What about wheels and tires? After all, we've established on several occasions that there's a fair amount of power to be gained (or lost) simply by using the right (or wrong) wheel/tire combo. So what did we do?

We got on the phone to Enkei and BFGoodrich and ordered three sets of wheels and tires. We called Rhys Millen and scheduled a day at the track with his Pikes Peak record-setting Mitsubishi Lancer, and we scheduled some time for acceleration testing with our long-term Mitsubishi Eclipse.

Lucky for us, the Eclipse and Lancer shared the same offset and bolt pattern, so our new Enkei wheels and BFGoodrich Comp T/A ZRs fit both cars. Here's the trick: The tires were three different aspect ratios but the same section width (225/50-16, 225/45-17 and 225/40-18). That means they had almost identical rolling diameters, allowing us to evaluate how the difference in rotating weight and sidewall height affects performance in a series of tests. More on that in a minute.

Tire choice was critical, as the tires would see both drag-race style acceleration and road racing loads during testing. We selected BFGoodrich's Comp T/A ZR only because the company's latest performance model, the g-Force T/A KD, wasn't available in 16-inch sizes and we needed the same tire in all three sizes to keep the comparison fair.

As for wheels, well, we wanted to stay reasonably light, so we used Enkei's NT03 in the 17- and 18-inch sizes. Enkei didn't have any 16-inch NT03s available at the time, so we used its RF1, another relatively light wheel.

THE TESTS

Here's where it got interesting. We had 12 wheels and tires, three cars, two racetracks, one radar gun and an infrared lap timer. How were we going to make sense of the whole mess? One test at a time.

GOING STRAIGHT

Acceleration testing was relatively simple. All we really needed was a car that would easily turn consistent quarter-mile times. Our long-term Eclipse fit the bill perfectly since it had already proven itself as unvaryingly consistent in the quarter mile and, as luck would have it, the Eclipse could use the same wheels as the Lancer.

Since the wheels fit both cars, we hoped to have a definitive answer to a question that's always in the back of our minds: What effect do plus-sized wheels and tires have on acceleration? We have, on several occasions, documented the effect larger wheels and tires have on at-the-wheels power output, but were yet to get a definitive measurement in acceleration.

Bigger wheels and tires weren't our only problem. What about old-fashioned ballast? You know, that extra friend that always comes along for the ride, adding an unnecessary 150 lbs of power-robbing weight to your car. How badly does he hurt acceleration? Is he going to cost you that extra car length at the stoplight grand prix? Should he be left along the side of the road?

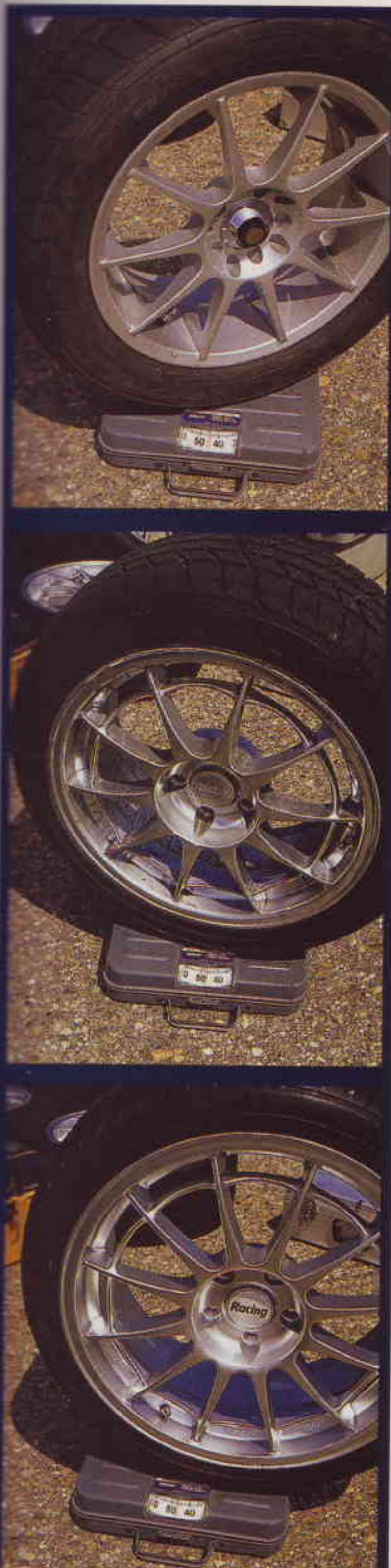
In the same vein, we realized the Eclipse, to be politically correct, is a relatively heavy car (3,050 lbs.); that extra pork would likely buffer the effect of our ballast until we reached ridiculously heavy loads. So, in an effort to get as much from this test as possible, we put FocusSport's ultra-light Ford Focus in front of our radar gun. The Focus, which is capable of running 14-second quarter-mile times all day, weighs in at a scant 2,160 lbs—perfect for our test and at the opposite end of the performance-car spectrum from the Eclipse. (You'll see more on this Focus in upcoming months.)

QUARTER-MILE TIMES BY WHEEL SIZE

2000 MITSUBISHI ECLIPSE GT

16-inch	15.5 sec. @ 89.4 mph
17-inch	15.5 sec. @ 89.0 mph
18-inch	15.6 sec. @ 87.9 mph

It should be noted that our wheel and tire choice presented us with an unusual set of wheel weights. In most cases, the smaller wheels were significantly lighter, but in our case, that didn't really work out. The 16-inch wheel and tire package weighed 44.5 lbs per corner, while the 17-inch package weighed 47 lbs per corner. That made sense so far, but the oddball was the 18-inch wheel and tire, which was actually slightly lighter than the 17-inchers, at 46 lbs. How did that work out? First, the 18-inch Enkei NT03 weighs only 1 lb. more than the 17-inch wheel, but the 18-inch tire is 2 lbs. lighter than the 17-inch tire. The only explanation we could find for this is that the



Contrary to popular belief, bigger isn't always heavier. All of our Enkei/BFGoodrich wheel/tire combos were relatively light. The 16s (top) weighed in at 44.5 lbs, but the 17s (middle) and 18s (bottom) were 47 and 46 lbs respectively.

shorter sidewall on the 225/40ZR18 shaves significant weight.

The Eclipse did its duty, making nearly identical quarter-mile runs over and over again. The variation from run to run was less than a tenth of a second, but for maximum accuracy, we averaged the four best runs with each configuration. Surprisingly, both the 16-inch and 17-inch setups returned 15.5-second quarter-mile times, but the 17-inch trap speed was slightly slower at 89.0 mph vs. the 89.4 of the 16-inch wheel. Actually, the 17-inch wheel's time was 0.04 seconds slower than the 16-inch wheel, but with just under a tenth of a second variation between the fastest and slowest runs in each configuration, we can't confidently claim thousandth-of-a-second accuracy. The 18-inch wheel returned the slowest time, with a 15.6-second average at 87.9 mph.

WHAT DOES IT MEAN?

The fact the 18-inch wheel was slower, despite being slightly lighter than the 17 suggests that rotational inertia is, indeed, a significant factor in acceleration. As weight is moved outward, rotational inertia increases with the square of the distance from the center of the wheel. Not only was the wheel rim a half-inch farther from the center (which alone would account for a 12-percent increase in rotational inertia), but the 18-inch wheel was 8 inches wide while the others were 7, making the rim a larger percentage of the wheel's weight.

But wait. Going from 16-inch wheels to 17-inch wheels also added weight and increased rotational inertia, so why wasn't there a bigger difference there? This inconsistency hints at the fact that there is some noise in our data. Even with a consistent car and a consistent driver, there are too many changing factors in a quarter-mile run to expect exact repeatability. While the trend seems correct, random variations seem to have slightly overstated the difference between the 17- and 18-inch wheels, and understated the difference between the 16s and 17s.

CHASSIS WEIGHT

Next up, it was time to start adding weight to the Eclipse. Beginning with the 16-inch wheels

on the car, we used the smallest amount of weight we could add: a single 50-lb sandbag. The result was not measurably slower at all. Again, we saw differences in the hundredths of a second and hundredths of a mile-per-hour—not significant enough to report. Adding 50 lbs. to a 3,050-lb. car was like putting a fly on a rhinoceros. The negligible effect of 50 lbs is significant in itself, however, as each change we made with the wheels was measurable. So going from 17-inch to 18-inch wheels, it appears, is like adding more than 50

QUARTER-MILE TIMES BY WEIGHT

2000 MITSUBISHI ECLIPSE GT

No ballast	15.5 sec. @ 89.4 mph
50-lbs ballast	15.5 sec. @ 89.4 mph
150-lbs ballast	15.6 sec. @ 88.6 mph
250-lbs ballast	15.8 sec. @ 87.1 mph

*WITHOUT BALLAST, CURB WEIGHT IS 3,050 LBS

QUARTER-MILE TIMES BY WEIGHT

2000 FOCUSSPORT FORD FOCUS

No ballast	14.7 sec. @ 93.1 mph
50-lbs ballast	14.8 sec. @ 92.0 mph
250-lbs ballast	15.0 sec. @ 90.8 mph

*WITHOUT BALLAST, CURB WEIGHT IS 2,160 LBS

lbs. to the Eclipse. Chew on that for a while.

Time for more weight. Another 100 lbs. of sand brought the total to 150 lbs. of sand, 3,050 lbs. of Eclipse, and 130 lbs. of driver for a grand total of around 3,330 lbs. That slowed things down a bit, with a new quarter-mile time of 15.6 seconds at 88.6 mph. Finally, with 250 lbs. of sand, or enough to entertain five pre-schoolers for an hour, the Eclipse strained to a 15.8-second quarter mile at 87.1 mph.

So 250 lbs. equates to about 0.3 seconds and about 3 mph in the quarter mile—at least on an Eclipse. Adding 250 lbs. increases the Eclipse's weight by slightly more than 8 percent, so what if we add the same weight to a lighter car? Stripped down to a scant 2,160 lbs., adding 250 lbs. of sand to the FocusSport Focus would increase its weight by nearly 12 percent.

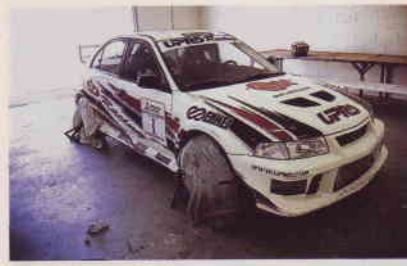
The difference was immediately apparent when adding only 50 lbs. added 0.1 seconds and chopped 1 mph off the Focus' quarter-mile speed. Adding the full 250 lbs., however, added only 0.3 seconds and took away only 2.3 mph. Again, this is noise in our data. The Focus was less consistent in its quarter-mile times than the Eclipse and the last run with 250 lbs. of sand benefited from an exceptionally good launch. We should have seen a slightly slower time with the heavily weighted Focus.

ROAD COURSE

Enough of this straight-line stuff. Big wheels and low-profile tires aren't designed for straight-line acceleration, the lower-profile tires are supposed to benefit handling by providing more immediate steering response and less deformation of the contact patch. That's the story anyway. Though we attempted to run our standard skidpad and slalom tests with the Eclipse, we found the Eclipse's suspension far less consistent and repeatable than its driveline. Handling data with the Eclipse simply varied too much to see any meaningful differences with wheel and tire changes. Instead, we headed to the Streets of Willow Springs where a consistent car and a consistent driver awaited us.

With Rhys Millen and Under Pressure Research and Development's Lancer on board, we knew we had a combination capable of consistent lap times. Our methodology at the track would be simple: Take everything we know about making a car go quick around a track and throw a wrench in the works. That wrench, in this particular case, would be any of our three sets of wheels or 250 lbs. of sand (in 50 lb. increments). Obviously, where we placed the weight would change the effect it would have, but safety and sanity limited where we could place our ballast. To prevent 50 lb. bags of sand from flying around inside the car, and to ensure that Millen didn't know when we had weight in the car and when we didn't, we secured the sand inside plastic bins in the rear seat area and in the trunk. Millen's consistent driving was nothing that 250 lbs of sand in the trunk wouldn't change.

We wanted Millen to go into every track session without any preconceptions of how the car would perform. Since the Lancer arrived that day shod with a set of Michelin rally tires and we showed up with the aforementioned Enkei/BFGoodrich combos, he really had no idea what he was getting into. It was his job to run until he produced consistent lap times. We'd record those times as well as the car's straightaway speed and get his impression of the car's dynamics at the end of each session.



Dressed to kill? Hardly. This was how the Lancer looked before Millen climbed in the driver's seat for each lap session. Hard to tell what wheel/tire combo we're using, isn't it?

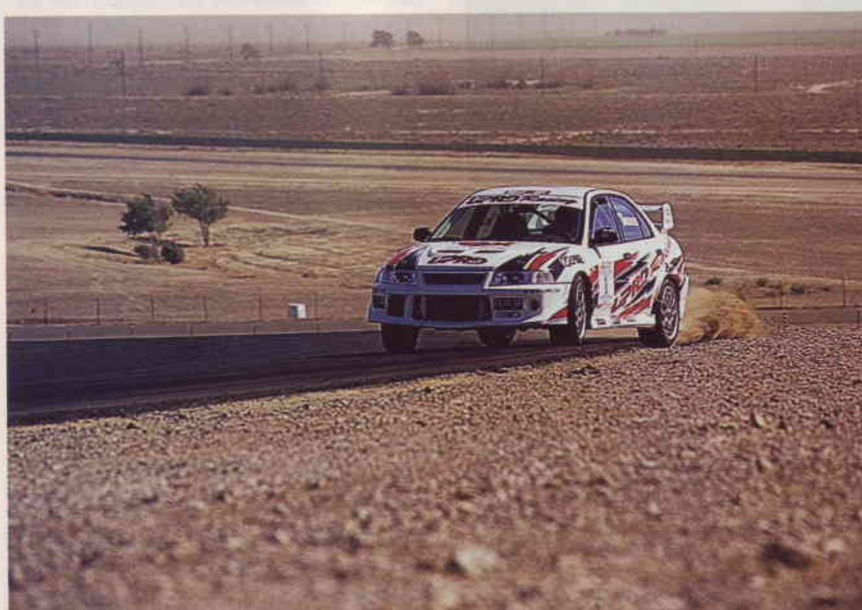
WHEELS

For the first three lap sessions, we changed only the wheel and tire package. Starting with 18-inch wheels, Millen made six hot laps and, as with the acceleration times, we averaged the fastest four. His average lap time was 1:03.92, with just a quarter-second variation between his fastest and slowest laps. At the end

LAP TIMES AND PEAK SPEED BY WHEEL SIZE

2000 MITSUBISHI LANCER

WHEEL SIZE	LAP TIME	STRAIGHT SPEED
16-inch	1:03.7	96.1 mph
17-inch	1:03.2	95.5 mph
18-inch	1:03.9	95.0 mph



Here's what happened when we added 200 lbs. of ballast to the back of the Lancer without telling Millen. He kept it on the road and still managed some respectable, albeit slower, lap times.

of the straight, the Lancer was going 95 mph. Not knowing what we had done to the car, Millen voiced a suspicion that we had added weight to the trunk, noting that it was unusually squirrely under braking. The Lancer was set up for gravel at the time, however—our test interrupted preparations for the Ramada Express International Rally—so perfect pavement behavior was not to be expected.

Switching to 17-inch wheels, Millen turned in a slightly faster 1:03.20, and straightaway speeds edged up to 95.5 mph. He commented that subjectively, the difference was slight, though there was now more grip and better stability under braking, but more understeer all around.

Back on track with 16-inch wheels, the lap times slowed again to 1:03.70, but at the end of the straight, he was going faster than ever, posting 96.1 mph. Millen's subjective comments were most revealing. "I'm not supposed to know what you did, is that right? It feels like it has tall, mushy sidewalls."

Hmmm.

WHAT DOES IT MEAN?

So far so good. We hid the changes from Millen to erase any preconceptions of what different wheel and tire combos should do, yet the results back up any preconceptions we would have had. We all knew taller sidewalls should feel squishy, but it was nice to have it confirmed. It was also good to see our acceleration results reflected in the top speeds on the straight. The smallest, lightest wheels went fastest at the end of the straight, even though their soft sidewalls cost lap time elsewhere on the course. Though the 18-inch wheels gave the most balanced handling (they garnered the least amount of complaints about understeer), their acceleration penalty made them slowest. It was the 17-inch wheels that offered the best compromise, in this case, between handling and acceleration.

The instability under braking? The braking zone at the end of the straight is actually in the exit of Turn 1, so braking was done while cornering. The sharper response of the short-sidewall 18s translated into bigger sideloads as the Lancer bounced over the slightly bumpy braking zone at more than 90 mph. That's a recipe for excitement. As the sidewalls got taller, the "mushiness" absorbed these shock loads, effectively stabilizing the car.

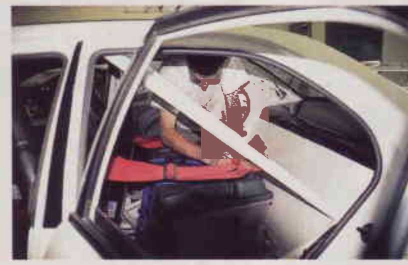
WEIGHT

Satisfied with our results so far, we wanted to see how much weight would affect lap times. For the first test, we added 100 lbs. to the rear seat and 100 lbs. to the trunk. Lap times jumped immediately to 1:04.73, slightly more than a second slower than the unladen car. Speed at the end of the straight dropped almost 2 mph to 94.2. Millen's most telling comment: "The car feels heavy!" He complained of sluggish acceleration out of the turns, more reluctant braking, excessive understeer and some very exciting tail-happy antics in the braking zone after Turn 1.

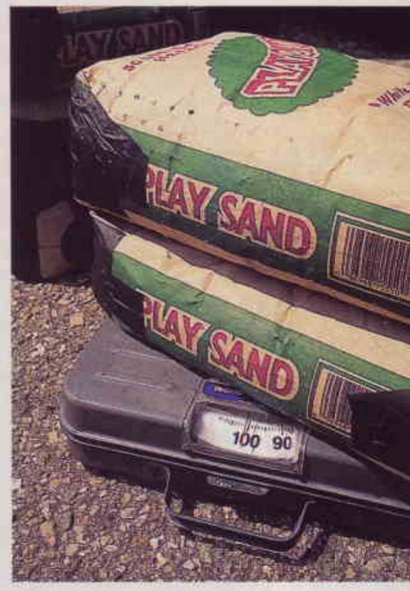
Pulling 50 lbs. from each bin, lap times

LAP TIMES AND PEAK SPEED BY WEIGHT

BALLAST	LAP TIME	STRAIGHT SPEED
No ballast	1:03.7	96.1 mph
100 lbs ballast	1:04.0	95.8 mph
200 lbs ballast	1:04.7	94.2 mph



Engineering editor Coleman straps ballast into a bin which kept it safely out of Millen's sight (above). Yes, two bags of play sand really do weigh 100 lbs (below).



recovered slightly to 1:04.00 and speed climbed back up to 95.8 mph, but Millen couldn't feel any difference.

WHAT DOES IT MEAN?

OK, so heavier cars are slower—big surprise. Here's the real surprise. Look at the lap times with 18-inch wheels and look at the lap times with 16-inch wheels and 100 lbs. of sand in the car. They are nearly identical. The car laden with 100-lbs of sand and fitted with 16-inch wheels is 0.1 seconds slower, but 0.8 mph faster on the straight. In reality, that's about a wash. The difference between 16-inch and 18-inch wheels here is roughly equivalent to that of 100 lbs of ballast. And that's with relatively light 18-inch wheels. We've seen countless 18 x 8-inch wheels that weigh as much as 10 lbs. more than the NT03, so the effect of those wheels would surely be more dramatic.

WHAT DID WE LEARN?

It's universally agreed that, in the performance car world, light is good and heavy is bad. But how much weight does it take before performance suffers? Not much, it turns out. Neither the Lancer nor the Eclipse are particularly lightweight cars, but weight differences of less than a typical passenger were measurable on both. With a lighter car, like the sub-Miata-weight FocusSport Focus, even the weight of a tank full of gas has a measurable effect on performance.

We also learned the relative importance of wheel weight. We have debated the many rules of thumb about rotating weight for years. We've attempted to prove them mathematically, we've attempted to measure them on a dyno, but this is the first time we've measured the effect on the track.

We'll stop short of issuing a new rule of thumb, though. "A pound on the wheel is equal to 50 lbs. on the car," or some such nonsense is too bold a statement to make with the few data points we have. All it takes is a casual glance at what we learned here, however, to see that the effect of wheel size and weight is sizable.

Should we all go out and buy 13-inch wheels? Maybe. The most critical part of the wheel/tire question, however, is the tire. A large part of the wheel size decision should be based on what tires are available. For example, if we decided we wanted the 16-inch wheels on the Lancer, we wouldn't be able to take advantage of the super-sticky BFGoodrich g-Force KD, which is only available in 17-inch and larger sizes. The benefit of extra grip over the 16-inch Comp T/A ZR would outweigh the slight penalty in weight.

The converse is also true. Don't assume the sidewall mushiness Millen observed with the 16-inch wheels will be a problem with all tires. Most 15- or 16-inch R-compound tires have sidewalls stiff enough to knock your teeth out, so if R-compound is your game, smaller is indeed better.

Building a fast car is a game of compromises and weight is but one piece of the puzzle. Now, however, it's a piece that you better understand. ■

We would like to extend a special thanks to all those who helped with this test, including Rhys Millen, UPRD, Enkei, BFGoodrich and the Wheel Warehouse in Anaheim, Calif. Our task would have been impossible had they not dropped everything to cater to our last-minute requests.