As a believer in the promise of electric vehicles (when better and, especially, cheaper batteries come along), I have followed with interest the development of the Model S sedan by Tesla Motors. When Tesla announced that their Model S would achieve 300 miles of driving range and be able to fully recharge its batteries in 45 minutes (using one of their own Superchargers, available only on their upcoming network of Supercharger stations) I was very impressed.

Then Tesla announced the sticker price for their 300 mile (85kWh) version, and later the fact that a full recharge required more than an hour. Then I further learned of the conditions under which they had obtained their 300 mile driving range (55mph). All this left me unimpressed, with both the car and Tesla's Rosy Scenario claims. Searching their website, I located (with difficulty) a graph containing Model S driving ranges, as a function of speed, upon which Tesla had based their 300 mile claim. It also described the test conditions: level terrain, no wind, no AC/heat, windows rolled up, constant speed, 300 pounds aboard. But, more importantly, it also displayed ranges for the car at speeds up to 80 mph. Speed destroys driving ranges in the same way it destroys mileage, being one and the same.

Further investigation of Tesla's website revealed a graph displaying HVAC penalties, also reported as a function of speed. Elon Musk had once stated in answer to a question that HVAC accounted for "5 to 10 percent" of the energy used by the Model S, thus reducing driving ranges by that those amounts. However, the graph, which apparently was the source for Musk's comment, clearly shows a 10 percent plus HVAC penalty at Interstate speeds and represents single data point information, i.e. it represents an average of HVAC penalties (over an unspecified time and an unspecified usage rate), not the maximum HVAC penalty implied by Musk's statement. I labeled this penalty "average AC/heat" in the range tables I subsequently constructed.

At this point I had very precise data concerning the effects of speed on Model S driving ranges, and pretty solid data concerning at least average AC/heating penalties.

Further research at online battery forums led me to a claim reportedly made by a Tesla battery engineer on another forum which provided battery deterioration rates (with respect to capacity, not power, which remains unknown). This allowed me to calculate expected changes in driving ranges as the battery ages.

Further research revealed that 75% of the 48 contiguous states have non-urban Interstate speed limits of 70 or higher. The rest are 65 mph, and those 65 mph Interstate Highways are usually located in smaller states, mostly in the Northeast. Texas has an 80 mph limit, and its portion of I-10 stretches 845 miles. Texas has more road mileage than all of New England, New York and New Jersey, combined.

Next, I attempted to identify other factors that would typically affect driving ranges during Interstate travel: vehicle load, rainy and/or wet road conditions, headwinds, non-level terrain. I disregarded the effects of rapid acceleration, which I consider (usually) insignificant during typical extended Interstate travel.

I was unable to obtain hard, reliable or detailed data concerning the effects of rainy weather and/or wet roadways (increased aero effects due to water mixed with the air, wiper motor usage, defrost or AC usage, lights, and, especially, the effects of a wet road on tire rolling resistance). However, comments from Prius owners led me to believe the effects can be quite significant. I also have no data concerning the effect of vehicle loading beyond that used by Tesla in their range tests (300 pounds).
Nor do I have data concerning the effects of non-level terrain, nor of headwinds.
Nor can I estimate the effects of a car full of passengers on heating or cooling, except to say that heating the interior will be easier and cooling more difficult with a full house.

Using the data which I was able to gather allowed me to construct two tables for each version of the Model S (40, 60 and 85 kWh), the first of which displays expected driving ranges as a function of speed and battery age (under ideal conditions), and a second, which adds the effect of "average" AC/heating to those expected ranges found in the first table. Then I constructed a third table for each version, for non-ideal driving conditions and/or heavier HVAC usage, such that an additional 15% of power was required beyond that represented in the second tables. The results were both interesting and discouraging. An example (from my tables, for the 85kWh version): at an age of 4 1/2 years, traveling at a constant 75 mph, under ideal driving conditions, but using average AC/heat, the table entry shows an expected driving range of 185 miles. Of course, one can never actually travel that far before having to stop for a recharge — the Supercharger stations in Tesla's supercharger network will not be located at every mile marker. If they average 40 miles apart (no one outside of Tesla knows at this point), the range would be reduced, on average, by 20 miles, or to 165 miles in this case, but it could be as little as 145 miles. Now assume a 15% penalty for non-ideal driving conditions and/or heavier AC/heating, and that 185 mile range shrinks to 153 miles, but would average 133 miles before having to stop, and conceivably might be as little as 113 miles. "Obtainable driving ranges" for each specified driving situation (using Tesla's Supercharger network) should themselves be expressed as ranges. In this last case, as "113 to 153 miles."

My guesstimate would be that somewhere around an hour and twenty minutes would be required for a full recharge, which includes the time required to get to and from the station from the Interstate, and also assumes no one is ahead of you at the recharge station.

I think it would be helpful if prospective Tesla Model S buyers were aware of the limitations of the vehicle, both when new, and down the road as its reported $40,000 battery pack loses capacity. Any driving range estimates that car reviewers might provide are unlikely to provide a true picture of what will be encountered during Interstate travel and almost certainly will not provide any information or warnings about what awaits Model S owners down the road, after years of (typical and expected) battery deterioration. "Real life" range tests that might be provided by reviewers are basically useless in providing range data where it matters most: while on extended travel, which invariably means non-urban Interstate travel. For example, the only range yet published was contained in the EPA tests, where they claimed a 265 mile driving range. Their highway test in no way resembles cruising down the Interstates. And they didn't use any HVAC. And they used a vehicle with a brand new battery, making their test more or less invalid (or at the very least, misleading) on that score alone. The data I gathered indicates that there exist no non-urban Interstate driving conditions under which a Model S can be expected to achieve the EPA's claimed 265 miles of range: the best that any Model S Interstate traveler would likely manage would occur while driving a 65 mph Interstate under absolutely ideal conditions, with no AC/heating and a brand new battery. His expected driving range under those conditions would be 262 miles.

I'd hate to think that all those prospective buyers have the idea fixed in their heads from Tesla advertising that their Model S will cruise along the Interstates for 300 miles (or even the EPA's 265 miles) before having to stop and recharge. What's worse, Tesla Motors is now offering a prize to any Model S owner who can demonstrate a 400 mile trip on a single
charge. Well, that's actually quite easy, provided you can find a road where you can drive at less than 38 mph for 12 hours or so, with level terrain, no AC, no heat, no stopping, and constant speed.