Improving the Show

by: Clifford Rassweiler
contact: cliffr@proev.com

Professional, as opposed to amateur auto racing, exists because advertisers pay the salaries and expenses of racing. These companies do this because a large number of people watch the races and buy the advertised products. The sales gained through motorsports advertising bring in more money than the racing costs. If it stops being profitable for the advertisers, they will go elsewhere.

In these harsh economic times, race series are desperately trying to improve the 'show' to attract new, and keep existing viewers. Their changes are quite radical. Formula One is adding computer controlled adjustable bodywork in hopes of increasing the number of passes during a race. NASCAR is requiring every team run the exact same body to try to guarantee close racing. Indy Car is requiring identical chassis but with different body work to lower costs but keep a veneer of technological competition.

Let's consider another radical proposal; racing electric cars.

Why race electric cars

It could be argued that electric cars should be raced as a way to help the fight against global warming. Alternative energy sources such as wind, solar and hydro produce electricity. The simple and direct use of this electricity for transportation is through electric vehicles. Electric vehicles are a cleaner, better solution to our transportation needs.

Electric vehicles generally do not have the speed, range or reliability of gas vehicles. If they are raced then, under the pressure of competition, race car engineers will find better solutions that force the pace of development.

But it is not the Professional Motorsport's Industry's ability to save the world or improve street cars that this article will focus on. Instead we will look at the intriguing possibility that electric vehicle racing will be able to provide a better 'Show', attract more viewers, keeping the sponsors happy and thus keep more motorsports professionals employed.

This study will require breaking the race into its basic components, understanding how each part adds or subtracts from the entertainment value of the event, and looking at how changing to electric vehicle racing might improve the spectacle.

Qualifying

Qualifying is a teaser for the race. The qualifying results get in the news and remind people that there will be a race to watch. It is a bonus for the fans (and advertisers). It is an additional opportunity to see the cars perform.

The possibility of passing makes the race exciting. If qualifying has put the cars in proper order of fastest to slowest and there is a fair start, there will be no passing. Not at the start. Not for the whole race. This is why qualifying needs to be a different challenge (a single fastest lap) than the race (fastest over the race distance). That means the optimum engineering solution for qualifying needs to be different from the optimum solution for the full distance to provide an exciting race.

Gas

The promoter wants to encourage the different nature of the qualifying competition to make it a separate 'show'. To do this, they commonly allow 'tricks' to make the car faster. This includes a low fuel load, 'one lap' super sticky tires, short life qualifying motors and most recently, the unlimited use of DRS (drag reduction system) in Formula One qualifying.

Electric

Electric racing will always have a faster qualifying pace than in the race. An electric motor's practical power limitation is the rate that the motor can shed heat. Motors have a peak (10 second) power rating and a lower continuous (or one hour) rating. Electric racers will be able to run their motors harder for a couple of qualifying laps than for the whole race without damage or extra cost.

ProEV's Electric Imp (http://www.Proev.com) can run a single lap with 230 horsepower in qualifying. For the race, the car needs to run closer to 160 horsepower to keep the motor from overheating. Changing the horsepower is something done in the software. There is no additional expense or work for the team to add around 30% extra horsepower.

Another factor that will mix up the order is that race pace and qualifying pace of electric race cars will be determined by different things. The key to qualifying is how powerful the car is. The key to the race pace is how efficient the car is - which determines how much power the car can run and still complete the race distance.

The rule maker must take into account that the elements that make an exciting race: the importance of drafting; the use of different race strategies; the overtaking; all conspire to lessen the importance of qualifying position. The promoters must find a way to assure the teams will put effort into qualifying well. There are positive reinforcements such as extra prize money for qualifying and/or Championship points for pole. Negative reinforcement might be limiting the number of starting positions to a lower number than the number of teams.

Race Start

The standing start is a great technique to change up the order. The ability to accelerate from a dead start and get around the first corner has nothing to do with the ability to do the single fastest flying lap that was tested in qualifying. It is a different challenge. Different challenges develop more versatile vehicles.

Gas

The difficulty of staging a standing start with internal combustion engines is that the engines need to be warmed up before they are stressed and the ICE race engine does not tolerate idling well. Therefore the organizer must get the start off in a small window between all the cars being warmed up and before the first cars overheat.

Electric

Electric motors do not have these problems. Electric motors do not idle. A standing start without a warm-up lap with cold tires and brakes will be even more challenging for the drivers and exciting for the fans.

Race laps

If one car pulls away immediately from the rest and goes on to win, it takes away from the spectacle but this is the risk of real competition rather than a staged performance.

Gas

There are a number of techniques to minimize this danger available to the savvy promoter. There is the creative use of yellow flags and safety cars to bunch the field. There is the technique of race to race 'reward' weights added to winning cars.

Steps can also be taken in the design stage to try and assure close racing. The closer the rules come to requiring a 'Spec' car (all cars built the same), the closer the racing should be. In a more open technology series, elements such as weight, power, fuel tank and tire size can be used to equalize performance.

It is also possible to write the rules to artificially magnify the importance of drafting. NASCAR's restrictor plate racing and open wheel racing's use of the Hanford device are examples.

Electric

Over most any race distance, electric race vehicles will be energy limited. Improving the efficiency of the electric race car is a more effective strategy than trying to carry more batteries because energy storage adds so much weight. Drafting allows a race car to use a great deal less energy to cover the same distance. Therefore drafting will allow a race car behind to conserve enough energy to keep challenging the car ahead of it.

One possible issue for organizers is that there might be some strategic negative incentive to leading the race. Drafting saves energy. When one car drafts another, they both save energy but the one behind gets more of a benefit. If the two cars have similar capacity battery packs, the car drafting from behind will save more energy during the race and have more energy for a last lap pass.

The model to look at is bicycle racing such as the Tour De France. The mass of racers tend to group together in the 'Peloton' where they get the most advantage from drafting (rumored to be up to 40%). When the stronger athletes think they can maintain a pace faster than that of the Peloton, they choose to go to the front and lose the benefit of the draft. They often pedal harder than their planned race pace in an attempt to break away from the pack so the others lose the benefit of drafting them. Often a small group of leaders will work together to out distance the main pack, taking turns in the most energy intense lead position. Each rider then must decide when to end the cooperation for the final sprint to the finish line.

If experience shows that races are starting too slowly because no one is willing to lead, then rule makers could add points for leading the first lap, leading the most laps or some sort of point structure for each lap lead.

Another issue to be considered is 'Team orders' and cooperation between drivers. From the modern bicycle racing model, it is clear that entering a number of racers to support a designated lead racer is an effective strategy.

Does this add or subtract from the spectacle? There is a lot of passion and drama in the NASCAR Chevy vs. Ford and the DTM Mercedes vs. Audi vs. Opel, but having the greatest number of vehicles in a team might be an overwhelming advantage. A two car limit on teams might allow cooperation but still lots of competition. The negative is that the individual racer might not be able to compete.

Warning: watch out for 'one use' battery packs

Successful racers design their car to the rules. Electric vehicle are at a point where race driven development can accelerate road vehicle development if the rules are written properly.

Batteries are the component that is most expensive, most temperamental and most in need of improvement. In battery design, there are indications that there exists an inverse relationship between energy or power density and battery life. Without rule restrictions, we should expect to see racers using very powerful batteries with extremely short lives. Racing these batteries will be extremely expensive and have little relevance to what electric vehicles need for road use.

A successful series must be designed to assure that battery energy/power density do not come at the expense of battery life.

A simple solution is for the series to have a 'spec' battery supplied to all competitors. The teams can focus on getting the most from the packs without actually developing the cells. A sealed 'spec' battery module with a built in Battery Management System that teams could tap to develop their own DAQ systems would be a solid advertising opportunity to a well funded battery manufacture.

Another possibility would be for teams to present their batteries at the start of the season; enough for a full pack and a set number of spares. The sanctioning organization would mark the cells and randomly choose one for testing. The cell would have to meet certain minimum requirements such as a specified number of complete charge/discharge cycles.

Writing and policing these rules will be one of the biggest challenges series organizers face.

Passing

A well executed pass by a skilled driver is often the highlight of a race. Even better (and rarer) is when two drivers pass and re-pass each other in a battle for position.

Gas

The discovery and refinement of aeronautic down-force has made passing difficult. Down-force generating devices such as wings and tunnels, work best in undisturbed air. This means the lead car will always have the advantage of better down-force than the following car. Additionally the disturbed air disrupts the front of the following car more than the rear. This throws off the car's balance and lessens the overtaking driver's control just when he needs it most. The more down-force involved, the greater the effect.

Promoters have attempted to address these problems by trying to legislate away down-force. Wing size is limited. The bottom of the cars is often required to be flat or well away from the ground. Despite these attempts, in every top series, aerodynamic down-force continues to be a key factor in making the car fast, and aeronautic instability a key challenge to passing.

Some series have addressed this issue by working to increase the ease and effectiveness of drafting. NASCAR sedans are an excellent example. It is always the following car who gains a power advantage by accelerating in the lead car's wake.

Other series have tried a 'Push to pass' or 'KERS' extra power button to give the overtaking car a burst of extra power to overcome the leading car's advantage.

There have also been experiments with lessening the effectiveness of the brakes and tires to lengthen brake zones in hopes that the drivers will have more reaction time to make a pass under braking.

Other ideas to create passing include highly artificial rules such as inverting the first 6 starting grid positions or requiring pit stops and different fuel or tire strategies. The rules can include more subtle means such as the penalizing drivers who use aggressive blocking to defend their position and high prize money/point differentials between finishing positions to improve the risk/reward ratio of trying a pass.

Electric

Aeronautic down force produces aeronautic drag. Experience has shown that designers are able to gain enough grip to increase the speed around the corners to offset the speed reduction from the drag. Aeronautic drag also increases energy use (fuel consumption). The extra weight of the extra fuel is a minor trade-off because fossil fuel is so energy dense.

The trade-off equation changes when the energy is stored in batteries. A minor increase in energy usage requires a significant increase in the vehicle's weight. If the vehicle is heavier, it is

harder to accelerate, to slow and to change direction. For a battery vehicle, lessening drag will be more important than creating down force.

Electric race cars with their focus on reducing drag will have much less down force. They will also have to handle well in the draft since drafting will be so tactically important. The car attempting to pass should always have the advantage.

Drivers will also have a 'Push to Pass' button, regulated by motor temperature and leaving enough energy to finish the race. Even braking distances will be a tactical choice. Friction brakes are more effective but throw away the energy that regenerative brakes recapture.

The Finish

A competition loses its audience's attention once it is clear who will win.

Electric

The end of an electric vehicle race will be a high speed chess match that will not be decided until the cars cross the finish line. Each vehicle will be trying to balance energy remaining with track position as the laps run out. The leader might only have enough energy left to maintain his race pace but cars further back might have conserved enough power for a final couple of qualifying pace laps. If the driver balances motor heat and energy remaining properly, any car could jump from far back for the win. The end of the race will be the most exciting point.

Conclusion

Part of the attraction of racing or any true sporting event is that it is a real competition whose outcome is not pre-determined. Artificial rules designed to 'improve the show' often detract from the reality of the competition. Electric vehicle racing has a real purpose- improving the cars we will be driving in the not too distant future and creating electric vehicles that the public will want to drive. Due to the different technical challenges of electric vehicles, electric vehicle racing should also provide better entertainment than today's well developed internal combustion vehicles.