

AXP Draft Guidelines – Revision Topics

Version 2

24 October, 2007

Introduction

We received close to 1000 comments on the [AXP Draft Guidelines](#)¹, covering many topics.

This document contains a highly-condensed distillation of the questions and topics that are being addressed as we revise the Guidelines. Many details covered in the comments are subsumed by the topics listed below. Some comments are not reflected here, mainly those that in our judgment do not justify reopening issues that were considered carefully during the revision cycles prior to the release of the Draft Guidelines.

For convenience, topics are listed below in Sections that correspond to those in the [Draft Guidelines](#). In some cases we just list a topic or question. In others, we identify the topic or question (“Issue”) and outline our current thinking.

Overview of the Automotive X PRIZE

- **Metric units. Issue:** Physical units are too U.S. centric. **Probable Change:** We will give equivalent metric units systematically. Since both EPA and CARB quantify Greenhouse Gas (GHG) emissions in the mixed units of g/mi, we will retain this measure, but we will also express the emissions in g/km (200 g/mi is 124.3 g/km).

Proposed Timeline

- **Race Timeline. Issue:** Completing the AXP in 2009 does not provide sufficient time for innovation. **Probable Change:** Assuming that we launch the AXP in early 2008, the AXP Qualifying Race will be no sooner than Q3, 2009, and the Final Race will be no sooner than Q2, 2010.

Registration

Applications

- More details needed about admissions requirements.
- Is the registration fee per-vehicle or per-team? Probably per-vehicle.
- Team funding must be predominantly from non-government sources. However, a modest amount of government funding will not be disqualifying if, in the opinion of the

¹ <http://auto.xprize.org/xprize/guidelines.html>

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AXP, there would be no conflict of interest with respect to the government agencies that are involved in AXP testing and judging.

Master Team Agreement (MTA)

- More details needed about media rights, confidentiality of team submissions, and other MTA contents, as well as the schedule for producing the MTA. (Note that LOI participants will be asked to comment on a draft.)

Vehicle Classes and Design Requirements

- **Vehicle Mods. Issue:** Many readers did not realize that vehicle modifications could be entered. (There was only one relevant sentence in the Draft Guidelines: “Vehicles that are designed to achieve AXP goals by modifying an existing popular vehicle may be entered in either class, provided that all AXP requirements are met.”) **Probable Change:** We will devote a section to this type of entry and provide more details on the requirements. For example, if the modification voids the OEM's original warranty, such that an OEM dealer will refuse to work on the car, the business plan must include reasonable steps by which servicing of the vehicle can be obtained from non-OEM sources.
- **Vehicle Weight. Issue:** Should we specify a minimum vehicle weight? A concern is that very lightweight designs may be unsafe. Another is that exotic materials required for such designs can be very expensive, unavailable in large quantity, and problematic from a recycling viewpoint. **Probable Answer:** Innovations are not predictable. We do not want to risk stifling innovation by imposing a weight minimum. Rather, we will rely on the safety judging panel to reject unsafe designs, and we likely add a requirement that team submissions include evidence that the vehicle is designed to meet the EU end-of-life directive (or something similar).
- **Battery (or other fuel tank) Replacement. Issue:** Some proposed designs involve innovative, rapid replacement of battery units for operating flexibility and convenience. Will that be permitted? **Probable Answer:** Yes, in general. But whether we allow a particular form of exchange will depend on the business plan presenting convincing evidence that the requisite technology and infrastructure will be in place. Furthermore, battery (or other fuel-tank) replacement will be considered as refueling the vehicle, and will be permitted during the races only when refueling is permitted.
- **Verifying the Design Requirements. Issue:** When and how will the static measurements and dynamic performance tests be performed? When and how will performance tests will be conducted (acceleration, top speed, gradeability, etc.). **Probable Answers:** Most of the measurements and tests will be performed in a special event that will take place prior to or during the AXP Final Race. Measurements and tests will be conducted by AXP together with an experienced partner organization. Certain tests (e.g., range, highway capability) will be conducted as part of specially designated Race stages.
- **Verifying Vehicle Range. Issue:** Measuring range using EPA's metric is not feasible since the procedures are not all developed for certain technologies. **Probable Answer:** As mentioned above, we will likely verify range by having at least one Race

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scoring stage of length equal to the minimum range. To the extent that EPA-style tests are developed by 2010, we may include them as well and combine them with the Race results in a manner similar to how we intend to combine EPA-style and Race fuel economy results. So-called “hypermiling” techniques will not be allowed and will be penalized by the race referees if detected via telemetry or observation.

- **Scoring the Design Requirements. Issue:** How will the results of static measurements and dynamic performance tests affect overall prize scoring? **Probable Answer:** To qualify for the Automotive X PRIZE, a vehicle must satisfy all of the design requirements that are specific to its vehicle class. Stated differently, the criteria for successfully completing the AXP Final Race includes the successful demonstration of all vehicle design requirements (in addition to competing all stages with a minimum average speed while meeting AXP energy and emissions requirements).
- Range and top speed requirements are discussed below in the Sections on minimum requirements for Mainstream and Alternative class vehicles. The other performance requirements (acceleration, braking, skidpad, slalom, gradeability) will also be reviewed for both classes, keeping in mind that they express absolute minimum (rather than desirable) requirements.

The following two issues are relevant to “Many Opportunities for Recognition” (covered later), but we mention them here because they likely will be covered in this Section of the revised Guidelines.

- **Vehicles in Both Classes. Issue:** Will there be any special recognition for vehicles that compete in both classes? **Probable Answer:** Yes, vehicles that compete in both classes will likely be eligible for a Best Overall Performance award. The algorithm for determining the winner(s) is to-be-determined, but might be as simple as adding the total race time over the two courses (note that the course for Alternative vehicles is a subset of the Mainstream course, so in this example the Alternative stages would count twice).
- **Production-Intent Designation. Issue:** Will the idea of a special Production-Intent designation be implemented? **Probable Answer:** Yes, teams may apply for this designation if they have the capability and clear investment plans to manufacture and sell the vehicle in the year after the Final Race, and vehicles with that designation will be highlighted in AXP publicity. More details are needed about the requirements for this designation (also, the final name for this designation has not been determined).

Minimum Requirements for All Vehicles

- Details are needed on vehicle specifications – interior space and comfort (dimensions), ingress/egress, operating temperatures, corrosion resistance, ground clearance, Marmon flange dimensions, etc. Although we will be guided by specifications of small, popular vehicles on the road today, we do not assume that market acceptability will remain the same in the future. We want to specify as little as possible, but also to avoid having AXP vehicles that are clearly unreasonable from the viewpoint of comfort, convenience, and utility.
- Details are needed on tire specifications, including estimated lifetime (probably at least 10K miles); estimated lifetime will likely be obtained via tread wear measurements

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before and after the AXP Races. Again, we want to specify as little as possible, but we want vehicle performance in the AXP races to represent the expected performance of production vehicles. Thus, for example, we want to rule out winning the race with tires that have to be replaced frequently.

- What are the specifications for heating and air conditioning?
- **Workmanship:** *Issue:* Will quality of workmanship (fit and finish) be judged? *Probable Answer:* We will not judge as part of “production-capable.” We will likely include in a subset of the AXP Awards that will be reserved for vehicles with the production-intent designation.
- **Modular-Vehicles:** *Issue:* Will modular vehicles (attachments for power, additional passengers, roadtrains, etc.) be permitted? *Probable Answer:* Only to the extent that they would be street legal in the U.S.
- Vehicles must have an OBD-II diagnostic port.
- Vehicles must be highway-capable; this will be addressed (in addition to acceleration requirements) by adding a requirement that vehicles be able to maintain 65 MPH against a light headwind.
- Regarding the requirement for rear and side view mirrors, see the discussion in the Section “[Judging Vehicle Submissions \(Safety\)](#).” Regardless, if an Alternative Class vehicle is legally classified as a motorcycle, we will permit a camera system in place of a rear-view mirror (since for motorcycles, side-view mirrors are considered rear-view mirrors).

Mainstream Class Requirements

- **Rear-occupant size.** *Issue:* Some successful mainstream vehicles have less rear-seat than front-seat space, so AXP should relax the requirement that both accommodate 95% males. *Probable Change:* Relative to the front seat, we expect to reduce somewhat the rear-seat requirement for headroom and perhaps other interior measurements.
- **Minimum range 200 mi.:** *Issue:* Should minimum range be increased from 200 mi. to at least 300 mi. since that would be more typical of mainstream vehicles today. *Probable Answer:* This is still under consideration. While popular “mainstream” vehicles today typically have a range of at least 300 miles, we are inclined to leave the range at 200 mi. since this is just a minimum and since it seems reasonable that consumers be able to consider tradeoffs between range and fuel economy. On the other hand, vehicle range is a proxy for how frequently the vehicle has to be refueled (whether or not people drive full range on a single trip). A different approach would be to specify a maximum refueling time. We will also consider leaving the minimum range as is, but having some race stages be considerably longer than 200 mi. with refueling allowed as needed to complete the stage (with no constraints on refueling time or amount).
- **Minimum top speed 100 mph.** *Issue:* Why require a top speed of 100 mph since that is far more than any legal speed limit and since some successful vehicles today have a top speed of 85 mph. *Probable Answer:* Still under consideration, but we are inclined to lower the minimum top speed requirement. The 100 mph minimum top

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speed was partly intended as a proxy for being able to accelerate safely to and maintain highway speeds, a concern we intend to address with the more-direct performance requirement that vehicles be highway-capable (mentioned earlier). We may also introduce a specific 40-65 mph performance test.

- **Tandem seating:** *Issue:* Given the likely change for Alternative Class vehicles (see below), should Mainstream seating requirements also be changed to allow tandem seating? *Probable Answer:* No.
- **Seating Orientation:** *Issue:* Apart from the driver, can passenger seats be rear-facing? *Probable Answer:* Yes.

Alternative Class Requirements

- **Tandem and single seating.** *Issue:* Given that this is the Alternative class, it should permit tandem seating and also single-seat vehicles. *Probable Change.* Our original concern was that tandem- and single-seat vehicles would have too much of an advantage, but we agree that they should be permitted. Thus, the probable change is to relax constraint on number of seats to one seat and not to constrain the seating arrangement. All vehicles must have automatic, dynamic and static stability (i.e., so that balance while moving or stopped/parked does not depend on the driver). However, we would have two Divisions of the Alternative class – side-by-side seating vs. everything else (tandem, single). There would be a winner in each Division with the Alternative class purse split between the Divisions in proportion to the number of vehicles in each Division (still under consideration).
- **Minimum range 100 mi.:** *Issue:* Should minimum range be decreased from 100 mi? The majority of vehicle trip lengths are considerably less than 100 mi, which suggests that there is a big market for vehicles with a shorter range. *Probable Answer:* Still under consideration. The counterargument, based on some historical evidence, is that consumers always want the option of driving further than normally required. On balance, we are inclined to reduce the range requirement from 100 mi. since this is just a minimum and since it seems reasonable that, as consumers become more concerned with fuel economy and carbon emissions, they will want to consider tradeoffs between range and fuel economy.
- **Driving Controls:** *Issue:* Do Alternative class vehicles have to drive like a car for familiarity (e.g., steering wheel). *Probable Answer:* No.

Team Submission Requirements

- Details needed on team submissions for Qualifying and Final Races.
- More details needed on confidentiality of team submissions.

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Judging Team Submissions

Safety

We are pleased to report that we have secured the assistance of NHTSA in resolving the issues discussed below.

- **Role of FMVSS. Issue:** More details needed on safety requirements derived from FMVSS (i.e., the safety requirements at a level above detailed homologation specifications). For example, will all FMVSS-mandated safety equipment be required? **Probable Answer:** We will provide a detailed list. On the particular question of installed safety equipment, we will require some (e.g., seatbelts) and not others (e.g., probably not airbags or ESC). However, we will require that all significant FMVSS-mandated safety equipment be part of the vehicle design (as presented in Team Submissions), and will require that race vehicles carry equivalent additional weight to compensate for the missing equipment.
- **Software Crash Testing. Issue:** Software crash testing may be prohibitively expensive for smaller teams. **Probable Answer:** If we require software crash testing, we will offer to assist teams in having it performed. Instead, we may require that the team submissions contain information sufficient for the AXP panel of safety experts to judge whether a production version of the vehicle is likely to comply with the crashworthiness standards and other applicable FMVSS requirements. Note that torsion and bending statistics do not result from crash testing
- **Innovations not Covered by Regulation. Issue:** What will be the safety requirements for innovations that are not covered by existing regulations or tested in marketplace? (e.g., large battery assemblies, fuel-cells, etc.). **Probable Answer:** We will likely require that the team submissions provide information (including a failure modes and effects analysis) sufficient for the AXP panel of safety experts to judge whether the innovation will pose a significant safety hazard.
- **Mirrors vs. Cameras (and analogies). Issue:** Several teams wish to use innovations that are not permitted under current regulations but they believe would improve fuel economy without compromising safety. A common example is the replacement of side-mirrors with full-view camera systems. Other examples include polycarbonate windshields and roadtrains. Will such innovations be permitted? **Probable Answer:** In general, the answer is no, since vehicles must be designed to satisfy all applicable regulations for U.S. sales. However, if there is strong evidence that a non-compliant innovation would improve fuel economy without compromising safety, and if we have reason to believe that the applicable regulations may change in the near future, the innovation will be permitted.
- For Alternative Class vehicles that are legally classified as motorcycles, what additional safety equipment or design features will be required beyond the legal minimum (occupant protection, fuel system integrity, etc.)
- What waivers will be required to operate the AXP vehicles during demonstrations and during the AXP Races, and how will those waivers be obtained?

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Cost

- Need details on how cost and manufacturability will be judged. Note that the target production rate is **at least** 10K/year (i.e., not just 10K).

Business Plan

- A detailed outline (template) is needed for the required business plan.

Figures of Merit for Energy & Emissions

- Both in comments on the Draft Guidelines and in discussions on the [AXP Forum](#)², there have been many good questions and suggestions about our approach to energy and emissions. The subject is complicated and requires both balance and compromise. Simplicity is paramount. We are still comfortable with our overall approach, but will do a more thorough job of explaining our reasoning in the FAQ section.
- Details needed on emission and fuel-economy testing for vehicles that are not covered by existing EPA/CARB test procedures (PHEV, EV, flex-fuel, etc.).

Energy (Fuel Economy) – 100 Miles per Gallon of Gasoline Energy Equivalent (MPGe)

- **Electric advantage. Issue:** Because AXP will measure fuel-economy pump-to-wheels (PTW), with upstream energy-conversion efficiencies not considered, does electricity have an unfair advantage? **Probable Answer:** After reconsidering all of the arguments on both sides of this question, we are inclined not to change the current requirement of 100 MPGe. However, we will be more thorough in explaining our position. One relevant point is that pure electric vehicles in fact have to achieve higher than 100 MPGe in order to meet the GHG emissions requirement. For example, given the currently-proposed limit of 200 g/mi based on the 2005 national grid, electric vehicles would have to achieve about 136 MPGe. (Note, however, that the GHG requirement may be adjusted somewhat – see below.)

Greenhouse Gas Emissions – Maximum 200 g/mi Total CO₂ Equivalent (CO₂e)

- **REET assumptions for GHG emissions. Issue:** In the energy and emissions [spreadsheet](#) published with the Draft Guidelines, the GHG emissions calculation is based on 2005 national data. The spreadsheet optionally can base the calculation on 2005 data from California – the difference is particularly significant in the case of electricity since renewable energy sources are more prevalent in California. Some have argued that for electricity the GHG calculation should assume emissions data that is somewhere between the 2005 data for the national grid and the California grid, on the grounds that over time the national grid will become cleaner (more like the 2005 California grid) as more renewable energy sources are introduced. Others argue that if a vehicle is intended for a regional market (e.g., California), the GHG emissions calculation should be based on regional data. **Probable Answer:** Uncertain. We continue to seek input on this issue, and will consider reducing the

² <http://auto.xprize.org/forum/index.php>

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upstream GHG estimates if there is a reasonable consensus on projections for 2010-2015. In cases where a team's business plan clearly calls for regional sales (at the required volume), we will consider estimating the upstream GHG emissions based on regional data.

- **GHG emissions maximum.** *Issue:* Some argue that the wells-to-wheels GHG emissions maximum of 200 g/mi should be lowered, in part to compensate for the efficiency advantage of electricity in pump-to-wheels fuel economy (MPGe). Others argue that the 200 g/mi (124 g/km) figure is too stringent and should be increased (note that the 2012 EU target for tailpipe GHG emissions is 120 g/km and, unlike the AXP requirement, does *not* include upstream emissions). *Probable Answer:* Still under consideration, but we will likely leave the requirement as 200 g/mi. As mentioned above, this limit is already low enough to require that electric vehicles achieve greater than 100 MPGe.
- Need to follow up on reports of spreadsheet errors and omissions.
- Note that WTW GHG estimates will be based on fuel used in the races (not on all possible vehicle fuels)
- We are considering whether HVAC emissions should be included in the WTW GHG cap.

Criteria Emissions – Tier II, bin 5

Details needed on specifics of criteria emissions test timing and procedure. We will not require SHED testing. Team submissions must include evidence that their vehicle is *designed* to pass 120K testing (rather than *likely* to pass). Estimates of 120K compliance may also be based on post-race testing with a standard deterioration factor.

Measuring Fuel Economy

- **AC on or off?** *Issue:* To what extent must climate control be on during the races? *Probable Answer:* In the interests of scoring simplicity and reliability, we will not require that climate control be used during scoring stages. However, we will require that climate control be used for non-scoring stages so that the public can see the impact (data will be reported for all stages). Furthermore, we will consider requiring air conditioning during fixed dyno tests in accordance with evolving EPA and other test standards.
- **Where is the pump/plug?** *Issue:* How will we account for PTW fuel energy if there is an off-board reforming or charging unit? *Probable Answer:* The “pump” is the termination point of fuel delivered by existing infrastructure – e.g., gas station pump, household electrical plug, etc. If there are energy conversion losses between that pump and the vehicle itself, they are counted in the fuel economy.
- Details needed on dyno testing (e.g., road load, soak durations, drive style variation, air conditioning, etc.).
- What is the proper weighting of dyno and in-race testing (is 50% the right mix?).
- We will not allow gaming via fast-charging of batteries that results in performance gains but premature aging. This is not meant to prohibit the use of innovative

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electrical energy storage devices that are expendable – i.e., inexpensive to replace frequently and can be recycled. (See also the discussion of battery replacement in the Section [“Vehicle Classes and Design Requirements.”](#))

- On-board sources of solar power (that operate while driving or when parked) will not be counted when computing MPGe, in the sense that the energy in the MPGe calculation will be based only on the energy transmitted to the vehicle at the pump. Thus, from the viewpoint of the MPGe calculation, such power sources are “free,” but of course they come at the expense of weight, complexity and cost.

Permitted Fuels

- We will revise the description of permitted fuels to not include a list of likely supported fuels. Rather, we will emphasize that to be accepted into AXP will require that a vehicle would be supported by the infrastructure that is available today or likely by approximately 2010. Thus the fuels supported by and provided by AXP will depend on the vehicles that are admitted to the Qualifying Race. In particular, the fuel must be readily available to the public (as defined and justified in the team business plan). In the case of electricity, for example, this means readily-available plug types and circuit capacities.
- Will standard fuel chemistry be specified?
- We have had a variety of questions about water (e.g., water injection). Regardless of its intended use, water would be considered to be a “fuel,” in that a water tank may be refilled only when refueling is permitted. Water would not have an upstream GHG “charge” and it would not have an “energy charge” (gasoline equivalence) in PTW calculations of fuel economy. (Of course, the water’s weight would affect fuel economy, and any on-board conversion to combustible fuel would involve energy consumption.)
- **Human-Powered Vehicles:** *Issue:* Will human-powered vehicles (e.g., via pedals) be permitted? *Probable Answer:* Rather than explicitly forbidding “human power” (humans turn the steering wheel, radiate heat, etc.), we prefer to rely on the vehicle performance specifications (acceleration, range, gradeability, highway-capability, etc.)

Race Concept and Course Design

AXP Stage Race Structure

- What non-scoring stages will be incorporated for vehicle stress testing (Baker Grade, Death Valley, test tracks, etc.) and at what time of year?
- What operating temperatures will the vehicles face?
- Details needed on how scoring stages will be chosen. For next version, provide more information on maximum distance, distributions of stage-length, distributions of different types of driving, and stage intervals.

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- Details needed on refueling rules (frequency, time limits). We may allow refueling during certain stages (most likely Mainstream long distance stages.)
- What weight must be carried on the race vehicle to simulate likely production weight?
- **Out of gas. Issue:** What happens if a vehicle runs out of gas (or breaks down) during a stage? Will there be a limit on the resulting time penalty? **Probable Answer:** Yes, we will limit the time penalty for break-down or exhaustion so that a vehicle can remain competitive if such events are rare.
- **Driver and Passenger. Issue:** What is the requirement for driver weight? Will a passenger be required? **Probable Answers:** Required driver weight will likely be average U.S. driver weight. A passenger will probably not be required, although we will likely require a 2-person minimum weight equivalent of 300 lbs (SAE guideline).
- What is the minimum average speed (maximum total allowable time) that vehicles must accomplish in order to complete an AXP Race successfully?

Vehicle Performance Simulation

- Details needed about the performance simulation software and when it will be available.

Many Opportunities for Recognition

- Need to clarify the hierarchy of recognition: Race Finalists, AXP Certified, AXP Award winners, AXP winners.

AXP Certified Mark

- **Use of AXP Certified Mark. Issue:** What are the criteria that will apply to continued use of the AXP Certified mark? **Probable Answer:** Rather than require periodic retesting, we will likely just permit the mark to be used by teams for one year after the AXP Final Race.

Production-Intent Designation

- Details needed on requirements for production-intent designation.
- Details needed on recognition that will be given to production-intent vehicles.

The AXP Awards

- Details needed on the AXP Awards – what awards will be offered, how do teams qualify, how will winners be chosen.

Sustainability

- Details needed on GHG emissions resulted from typical vehicle production (so that teams can provide evidence that emissions resulting from the production of their vehicle would be no worse).

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- As mentioned in the Section “[Vehicle Classes and Design Requirements](#)” (Vehicle Weight), we will likely require evidence that the vehicle is designed to meet the EU end-of-life directive (or something similar).

Additional Outreach

- Details needed on talent, technology, and investment marketplaces.

Ideas for Public Participation

- Details needed on how AXP will incorporate public opinion.

Competition Fairness and Equity (Judging)

- Details needed on the structure of judging panels and their operating procedures (including appeals).