



energy | innovation | sustainability | engineering | design

RULES FOR THE 2016 HUMAN POWERED VEHICLE CHALLENGE

INDIA



Table of Contents

I.	General Information.....	7
A)	Objective.....	7
B)	Superiority of Rules	7
C)	Location	7
D)	Schedule Summary & Host Information.....	7
E)	Competition Summary	7
F)	On-Site Schedule	7
II.	General Rules of Competition	8
A)	Minimum Number of Vehicles to Compete.....	8
B)	Events of the Competition	8
C)	Modification of Vehicles	8
D)	Aerodynamic Devices	8
E)	Vehicle Number and Logos	9
F)	Fairness of Competition.....	9
G)	Protests.....	9
H)	Event Scoring.....	9
I)	Energy Storage Device	9
J)	Report Publication	10
K)	Readiness to Compete.....	10
III.	Safety	10
A)	General.....	10
B)	Performance Safety Requirements.....	10
C)	Rollover Protection System	10
D)	Safety Harness	12
E)	Exemptions	13
F)	Vehicle Hazards	13
G)	Clothing and Protective Equipment.....	13
H)	Required Safety Test of Energy Storage Devices.....	13
I)	Safety Certification	14
J)	Safety Inspection and Demonstration	14
K)	Modifications	14
L)	Disqualification of Unsafe Vehicles	14
IV.	Entry and Registration	15

A) Team Eligibility	15
B) Team Member Eligibility and Certification.....	15
C) Verification of Team Rosters.....	15
D) Qualification	15
E) Vehicle Design, Analysis, and Construction	15
F) Submittal of Final Entries	15
G) Late Entries	16
H) Entry fees	16
I) Refund of Entry Fees	16
J) Notification of Acceptance	16
K) Competition Information	16
L) On-Site Registration.....	16
M) Late registration	16
V. Qualification	17
A) Objective	17
B) Description.....	17
C) Submission Deadline	17
D) Notification of Qualification Results	17
E) Non-participation	18
F) Number of submission per school.....	18
G) Unique Proposals	18
H) Scoring	18
VI. Design Event.....	19
A) Objective	19
B) Description.....	19
C) Design Report	19
D) Design Report Organization	20
E) Design Report Content.....	20
F) Prior Work	23
G) Design Report Submittal.....	24
H) Late Reports	24
I) Design Presentation	24
J) Static Judging.....	24
K) Vehicle Display.....	25

L)	Design Scoring.....	25
M)	Design Score Penalties.....	25
N)	Overall Design Scoring.....	25
VII.	Speed Event (Sprint or Drag Race).....	26
A.	Sprint Race.....	26
A)	Objective	26
B)	Description.....	26
C)	Sprint Course Description.....	26
D)	Timing Area	27
E)	Tally Board	27
F)	Drivers' Meeting	27
G)	Starting Order.....	27
H)	Line Position Forfeiture	27
I)	Start Assistance	27
J)	Number of Attempts	27
K)	Interruption and Termination.....	28
L)	Scoring	28
B.	Drag Race.....	28
A)	Objective	28
B)	Description.....	28
C)	Duration	28
D)	Drag Course Description.....	28
E)	Timing Area	28
F)	Tally Board	28
G)	Drivers' Meeting.....	28
H)	Race Description.....	29
I)	Qualifying Race	29
J)	Female Driver Qualifying Race Bonus.....	29
K)	Brackets And Seeding.....	29
L)	Drag Race.....	29
M)	Female Driver Drag Race Bonus	30
N)	Race Forfeiture.....	30
O)	Start Assistance	30
P)	Interruption and Termination.....	30

Q) Scoring	30
VIII. Innovation Event	31
A) Objective	31
B) Description	31
C) Definition of Innovation	31
D) Target Innovation Areas	31
E) Report	32
F) Presentation	33
G) Team Check-In	33
O) Innovation Score Penalties	34
P) Scoring	34
IX. Endurance Event	34
A) Objective	34
B) Description	34
C) Endurance Course	34
D) Start	35
E) Pits	35
F) Start Assistance	36
G) Obstacles	36
H) Parcel Pickup and Delivery	38
I) Lap Counting Process	39
J) Driver/Stoker Requirements	39
K) Judging Area	40
L) Drivers' Meeting	40
M) Course Practice	40
N) Signals	40
O) Disabled Vehicles	41
P) Fouls and Penalties	41
Q) Interruptions	42
R) Termination	42
S) Female Driver Bonus	42
T) Scoring	42
X. Overall Scoring	43
XI. Announcement of Results and Awards	43

A)	Announcement of Results	43
B)	Presentation of Awards	43
C)	Competition Awards	43
D)	Other Awards	44
XII.	Clarification and Modification of Rules	44
A)	Clarification and Modification of the Rules	44
B)	Chief and Head Judges.....	44
XIII.	Appendix 1 Registration and Documentation Submittal	45
XIV.	Appendix 2 Design Event Judge’s Score Sheet.....	46
XV.	Appendix 3 Innovation Event Judge’s Score Sheet.....	49

I. General Information

- A) *Objective* To provide an opportunity for engineering students to demonstrate application of sound engineering principles toward the development of fast, efficient, sustainable, and practical human-powered vehicles.
- B) *Superiority of Rules* These rules have been established by the ASME's Human Powered Vehicle Challenge (HPVC) Committee. Should any conflict arise between these rules and those of the ASME, the ASME rules shall dominate. Should any conflict arise between these rules and other information regarding the ASME HPVC, whether generated by the ASME or any other organization, these rules shall dominate.
- C) *Location* Locations of all competitions can be found on the official HPVC website. Teams wishing to participate should consult the HPVC website, ASME HPVC Community on Facebook, and HPVC Questions Forum.

Official HPVC Website: <https://community.asme.org/hpvc/default.aspx>

Official Rules and Forms: <https://community.asme.org/hpvc/m/default.aspx>

HPVC India Website: <http://www.hpvcindia.in/>

HPVC Facebook Community: <http://www.facebook.com/ASMEHPVC>

HPVC Question Forum: <https://groups.google.com/forum/#!forum/asme-hpvc>

- D) *Schedule Summary & Host Information* The ASME HPVC website shall specify all the important dates and contact information for the relevant competition.
- E) *Competition Summary* The competition shall include four events: a design event, a speed event, a technology innovation event, and an endurance race. Scores from each event are totaled to obtain the overall score to determine the winner.
- F) *On-Site Schedule* On-site registration generally begins on Friday morning of the competition. All teams must register in person before the end of the registration period. The full schedule of events is posted on the ASME HPVC website.

II. General Rules of Competition

- A) *Minimum Number of Vehicles to Compete* There is no requirement for a minimum number of vehicles. However, should the number of vehicles entered be more than one but less than four, the number of awards granted for overall placement in that event shall be one less than the number of competing vehicles.

To be eligible for overall 1st, 2nd, or 3rd place winner, a vehicle must compete and score in all four competitions. In the endurance event, a vehicle must complete at least 10 kilometers in order to meet this requirement.

B) *Events of the Competition*

- Design Event: Teams are scored on their application of sound engineering principles and practices toward a vehicle design. This event includes a written report, a technical presentation, and static judging of their design.
- Speed Event: Teams are scored on the speed of their vehicles, either in a flying start 100 meter sprint or a head-to-head drag race from a standing start. The ASME HPVC Committee will announce which event will be held well in advance of the competition.
- Innovation Event: Teams are scored on the design and demonstration of a technical innovation related to their vehicle.
- Endurance Event: Teams are scored on speed, practicality, performance and reliability of their vehicles in a road race format with typical urban transportation obstacles.

- C) *Modification of Vehicles* Modifications to the vehicle are allowed between events, as long as safety is not compromised. Vehicles must retain their main frame and general drivetrain configuration. Any vehicle deemed to have undergone changes in excess of this allowance will be permitted to compete if it does not present a safety risk; however, any scores achieved will not be credited to the original entry. Vehicles in which the basis of design involves changes to the main frame or drive train configuration for various racing events must submit a request for a waiver prior to the report due date.

- D) *Aerodynamic Devices* Each vehicle shall include components, devices, or systems engineered specifically to reduce aerodynamic drag. Front fairings, tail sections, and full fairings are encouraged. Other devices may be permitted providing they clearly demonstrate that the device or system significantly reduces aerodynamic drag. The effectiveness of such devices must be justified in the design report.

Vehicles may compete in racing events without aerodynamic devices, but full design points shall not be awarded without analysis and testing of the aerodynamic device. Makeshift devices which are unrepresentative of the design, are crudely crafted, and/or present a clear safety concern will be prohibited, and must be removed prior to racing unless granted a waiver by the Head Judge.

Fairing configurations may be changed between events in accordance with Section II provided that all safety requirements, including the seat belt and Rollover Protection System (RPS) rules, are not compromised by the change of configuration.

- E) *Vehicle Number and Logos* ASME will assign each vehicle a number. The number "1" will be assigned to the overall winner from the prior year's competition. All other numbers will be assigned by ASME. At its discretion, ASME may consider requests for specific vehicle numbers, but no zero or triple digit numbers will be allowed.

Decals –ASME will provide two adhesive decals to each team during the on-site registration process. Each decal will display the assigned vehicle number as well as the ASME logo. Each vehicle shall provide sufficient space on either side for these stickers. This space may include fairings, cargo containers, or surfaces especially designed for this purpose. The decals shall be no larger than 35 x 30 cm. If one or both of the ASME decals are lost, obscured, or difficult to see from either side of the vehicle, the vehicle shall be removed from the competition until they are restored. If a vehicle number is obscured during an endurance race, any laps run without a visible number will not be counted.

School Name – All vehicles should display their school name or initials on each side of the vehicle in characters at least 10 cm high in a color that contrasts with the background.

- F) *Fairness of Competition* All participating teams will be assured an equal opportunity and a fair competition. Any participating team that, in the reasoned opinion of the judges, seeks to exert an unfair advantage over other competitors will be subject to a penalty in performance points or disqualification from the competition.
- G) *Protests* Protests must be announced to a member of the judging staff either at the time of the incident or within a 15 minute period following the announcement of results of the event. Following the announcement of the intent to protest, a written protest must be presented within 30 minutes unless otherwise allowed by the Head Judge. Oral protests will not be recognized.

Protests must be specific in nature and must include a factual account of the event being protested and the specific rules infraction, or the perceived error in the scoring of an event. ASME HPVC Form 7 may be used to file a protest. This form is available on the Official HPVC Website.

Protests will be examined and resolved by the judges at their earliest convenience during the competition. Their decision will be final and without further appeal.

- H) *Event Scoring* Scoring for each event and the overall scores will be based on a points system. The team with the most points wins the event.
- I) *Energy Storage Device* Vehicles may employ the use of energy storage devices for purposes of accelerating and improving performance of their HPVs, but by no means are they required. If energy storage is used energy must be stored while the vehicle is in motion, with human power as the sole external source of energy. Prior to each race, each team must demonstrate that their storage device has no initial energy stored. Combustion engines are excluded from the competition.

Energy storage devices are permitted in the Technology Innovation event, and all energy storage devices should be compatible with the spirit of the competition with respect to energy conservation and environmental stewardship.

During the safety inspection the team must be prepared to discuss the safety of the storage device, especially during a high-speed incident. Teams whose vehicles present an unacceptable risk in the perception of the judges will not be allowed to utilize the energy storage device in the competition.

Stored energy used to power non-motive systems (does not impart momentum to the vehicle) is allowed and may be stored prior to the beginning of the race.

- J) *Report Publication* After the completion of the events for a particular HPVC all team's design and innovation reports will be published to a shared site.

If a team does not want their design and/or innovation reports posted publically the team must submit a request, in writing, to the event Head Judge no later than the report due date. The request must convincingly outline the grounds (such as active NDAs, or submission for intellectual property) for which the request is being made, and teams must be prepared to present an alternative submission omitting any specific sections in question. Requests will be granted or denied by the judging committee, and their decision will be final and without appeal.

- K) *Readiness to Compete* Teams must show up ready to compete and repair facilities will only be provided if the host school offers. The host is not responsible for assistance with vehicle repairs.

III. Safety

- A) *General* The safety of participants, spectators, and the general public will override all other considerations during the competition. The judges will consider the safety features of the competition courses, as well as those of the competing vehicles, in permitting each event of the competition to begin or continue. Any event of the competition may be delayed, terminated prematurely, or canceled if the Head Judge, in consultation with ASME and the Judging Team, determines that such action is necessary in the interest of safety.
- B) *Performance Safety Requirements* Each vehicle must demonstrate that it can come to a stop from a speed of 25 km/hr in a distance of 6.0 m, can turn within an 8.0 m radius, and demonstrate stability by traveling for 30 m in a straight line at a speed of 5 to 8 km/hr (fast paced walking speed).
- C) *Rollover Protection System* All vehicles must include a rollover protection system (RPS) that protects all drivers in the vehicle in the event of an accident. Functionally, the RPS must:
- Absorb sufficient energy in a severe accident to minimize risk of injury
 - Prevent significant body contact with the ground in the event of a fall (vehicle resting on its side) or rollover (vehicle inverted)
 - Provide adequate abrasion resistance to protect against sliding across the ground.

In order to demonstrate the effectiveness of the RPS in protecting body contact from the ground teams may be required, during safety check, to lay their vehicle on its side as well as invert it

fully with the largest rider inside. Once laying on its side and inverted the rider must not make contact with the ground and if safety is compromised vehicle modifications will be required or vehicle will not be allowed to race.

In addition, the RPS shall meet the top and side load requirements described below.

- 1) RPS Load Cases: The RPS system shall be evaluated based on two specific load cases – a top load representing an accident involving an inverted vehicle and a side load representing a vehicle fallen on its side. In all cases the applied load shall be reacted by constraints on the vehicle seat in an inverted or side position with drivers strapped in and clipped in to the pedals.

- (a) Top Load: A load of 2670 N per driver/stoker shall be applied to the top of the roll bar(s), directed downward and aft (towards the rear of the vehicle) at an angle of 12° from the vertical, and the reactant force must be applied to the roll bar attachment point and not the bottom of the roll bar (unless the bottom is the attachment point). Note that there may be one roll bar for the driver and another roll bar for the stoker which will result in each RPS having an applied load of 2670 N, or the driver and stoker can both be protected by a single roll bar which will result in the RPS having an applied load of 5340 N.

The roll bar is acceptable if 1) there is no indication of permanent deformation, fracture, or delamination on either the roll bar or the vehicle frame, 2) the maximum elastic deformation is less than 5.1 cm and shall not deform such that contact with the driver's helmet, head or body will occur.

- (b) Side Load: A load of 1330 N per driver/stoker shall be applied horizontally to the side of the roll bar at shoulder height, and the reactant force must be applied to the roll bar attachment point and not the other side of the roll bar. Note that there may be one roll bar for the driver and another roll bar for the stoker which will result in each RPS having an applied load of 1330 N, or the driver and stoker can both be protected by a single roll bar which will result in the RPS having an applied load of 2670 N.

The roll bar is acceptable if 1) there is no indication of permanent deformation, fracture or delamination on either the roll bar or the vehicle frame, 2) the maximum elastic deformation is less than 3.8 cm and shall not deform such that contact with driver's helmet, head occurs.

- 2) RPS Attachment The RPS must be structurally attached and braced to the vehicle frame or fairing and, with the vehicle in the upright position, must extend above the helmeted head(s) of the driver(s) such that no part of any driver will touch the ground in a rollover or fall over condition. The RPS may be incorporated into the fairing, providing that that part of the fairing is used in all events. Teams must demonstrate that the RPS meets both functional requirements and loading requirements.

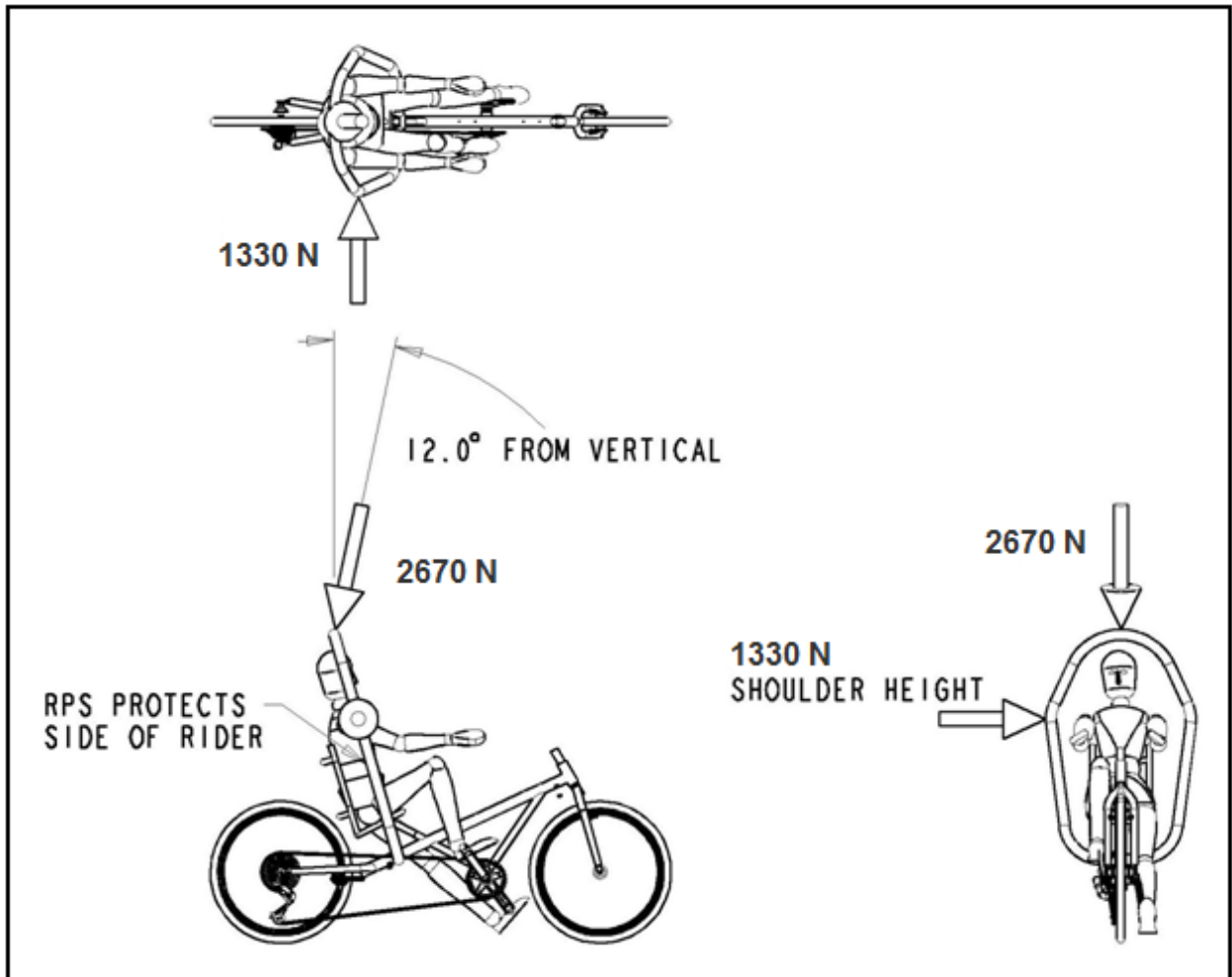


Figure 1: Example of Proper RPS Design and Side and Top Load Case Applications (Note: Loads shown should not be applied concurrently in analysis and/or testing)

- D) **Safety Harness** All drivers of all vehicles in all events will be secured to their vehicle by safety belts and, where feasible, shoulder harnesses at all times that the vehicle is in motion. Commercially available seat belts and harnesses designed for automotive, aviation or racing applications will generally be accepted without test data for the straps and buckles. Test data for attachment points may still be required.
- 1) **Custom Fabricated Harnesses** If the harness is custom fabricated by the team or a commercial entity not in the business of producing harnesses or webbing products designed for use in life supporting application (i.e. climbing, racing, automotive), significant test data will be required, as defined below.
- Hand stitching of webbing is not acceptable under any situation. Machine stitching will be acceptable with supporting test data.
 - Webbing connections secured with a properly tied water knot will be accepted without test data.
 - The minimum acceptable width for harness webbing is 25mm.

2) Testing requirements for non-commercially produced harnesses

- Tensile test samples of a stitched joint must be prepared in an identical manner to the intended production method including: Base webbing material, thread, stitching pattern and quantity.
- Tensile tests performed on a minimum of 5 samples must show a 95% statistical confidence of an ultimate strength in excess of 3340 N.

3) Testing requirements for off application buckles

- Off application is defined as a buckle designed for anything other than a life supporting applications (automotive, aviation, climbing, etc.). Other buckles designed for life supporting applications will be accepted without testing documentation.
- Plastic buckles of any type are not permitted.
- Tensile tests performed on a minimum of 5 samples must show a 95% statistical confidence of an ultimate strength in excess of 3340 N.

E) *Exemptions* Any team may request an exemption from rule **Section III C)** and/or **Section III D)** using HPVC Form 4 which is available on the Official HPVC Website. The request must be based on the safety of the driver or general public, and must be submitted in writing to the Head Judge no later than the Entry Date. The request must convincingly argue that safety is enhanced by omitting the safety harness and/or the RPS. Waivers will generally not be granted for fully faired vehicles, recumbent vehicles, or vehicles with three wheels. Requests for waivers will be granted or denied by the judging committee, and their decision will be final and without appeal. **Without a waiver granted by the judging team, teams without the RPS and/or safety harness will not be able to compete in any racing event.**

F) *Vehicle Hazards* All surfaces of the vehicle—both on the exterior and in the interior in the region of the driver(s) and in the access area—must be free from sharp edges and protrusions, open tube ends, screws protruding more than three threads, and other hazards. All drivetrain components and wheels must be fitted with appropriate guards if within reach of the rider.

G) *Clothing and Protective Equipment* All participants must wear closed toe shoes, appropriate clothing, and properly fitting helmets with fastened straps that meet CPSC Safety Standard for bicycle helmets (16 CFR Part 1203) or equivalent while:

- Warming up or orienting themselves on any event course
- Riding in the Sprint or Drag Race, Endurance Event, and safety check
- Riding any competing vehicle or other human powered vehicle on or in close proximity to an event course.

Note that this requirement applies to all participants riding any HPV or bicycle, including personal vehicles.

H) *Required Safety Test of Energy Storage Devices* Vehicles that utilize energy storage devices shall specifically address the safety of the device or system in the design report and during the safety inspection. In particular, safety in the event of a high-speed accident shall be addressed. Teams whose vehicles present an unacceptable risk in the perception of the judges will not be allowed to utilize the energy storage device in the competition.

- I) *Safety Certification* Participating teams must certify using HPVC Form 3 that:
- **All drivers and stokers will have had no less than 30 minutes of riding experience in their vehicle prior to the competition.**
 - Each team shall present a ride log at registration that clearly indicates the operator's name, date, duration in hours and minutes, and location for each ride or vehicle test used to satisfy the safety certification requirement.
 - The design and construction of their respective vehicles have been carried out with due consideration of occupant and bystander safety.
 - The specified safety tests will have been completed before arrival at the competition.
- J) *Safety Inspection and Demonstration* A competition official shall oversee tests of each vehicle's ability to meet the braking, turning and forward motion requirements. Each vehicle shall be visually inspected by the judges to ensure that no hazards exist that are likely to cause harm to the driver, passengers, competitors or spectators. Potential hazards include but are not limited to defects or play in the steering system, sharp edges, protruding bolts, open tube ends, and pinch points. In addition, the vehicle must provide the driver with a field of view of at least 90° to right and left of vehicle front and center.

The rollover protection system must appear substantial and correctly installed. The tallest driver on the team must sit in the vehicle and demonstrate the roll bar assembly extends beyond the driver's helmeted head and shoulders.

The safety check will take place during the scheduled safety inspection time block. No vehicle will be allowed to participate in any race unless it has successfully completed the safety check. Any team that fails the safety inspection may petition the safety judge for a re-inspection at a later time. Such re-inspection will be granted at the sole discretion of the safety official based on available time. If the re-inspection occurs after the designated inspection time block for that team, the team may be assessed a design score penalty up to 10%.

- K) *Modifications Affecting Safety* Modifications to vehicles between events of the competition must not compromise the safety of the vehicle. If the competition officials determine that any modification has reduced the safety of the design to an unacceptable level, the vehicle will be disqualified from the affected event of the competition.
- L) *Disqualification of Unsafe Vehicles* The competition officials reserve the right to remove, from the competition, any vehicle that is judged to be unsafe. This includes consideration of a vehicle's perceived performance under prevailing weather conditions.

IV. Entry and Registration

- A) *Team Eligibility* Entry in the Human Powered Vehicle Challenge is open to teams from any school with an engineering program.
- B) *Team Member Eligibility and Certification* All members of the respective school's team must be enrolled as full-time students in an engineering program of study at that school. Any individual that has been enrolled as a full-time student in an engineering program of study during the previous semester or quarter, but graduated no earlier than six months prior to the competition date, is eligible to fully participate in the ASME HPVC.

Entry submission must include names, ASME membership numbers, and academic majors of all team members. The final entry submission must be received by the Entry Date using either the online registration site, or HPVC Form 2.

The team roster must clearly identify all designated drivers. Only those individuals thus identified and certified will be allowed to participate as vehicle drivers at any time during the competition. **No driver shall compete in multiple entries in any single racing event.**

- C) *Verification of Team Rosters* Each team roster must be signed by the designated Team Leader. ASME may, at its discretion, submit a copy of any team's roster to the respective school's registrar's office for verification of enrollment and academic major.
- D) *Qualification* Each team must submit a qualification proposal before the posted deadlines in order to be eligible to compete in the competition. See the Qualification section for the details.
- E) *Vehicle Design, Analysis, and Construction* The research, analysis, and design of all vehicles entered by a school must be performed solely by current students at that school. All student team members shall be listed on the team's certified roster. Construction of the vehicle may include the assistance of outside vendors where the required capabilities exceed those available at the school.
- F) *Submittal of Final Entries* Final entries must be received by the published entry date and must include the following:
- A completed entry form (HPVC Form 1)
 - The registration fees
 - Identification and certification of eligibility of team members (HPVC Form 2)
 - A signed certification of vehicle safety (HPVC Form 3)
 - If required, a Safety Exemption Request (HPVC Form 4)
 - An acknowledgment of understanding of the rules, or requests for clarification or variance (HPVC Form 5)
 - A description of the vehicle (HPVC Form 6; Attached to design report)
 - A top level 3-view engineering drawing of the vehicle (Attached to design report)

NOTE: Online registration satisfies all requirements for Forms 1, 2, 3 and 5, as well as the registration payment requirement.

- G) *Late Entries* At its sole discretion, ASME may consider entries received after the entry date.
- H) *Entry fees* The entry fees for the competition may differ depending on site. The specific fees will be outlined on the competition website.
- I) *Refund of Entry Fees* If an entry is not accepted, all fees will be returned. If a school requests a cancellation of an entry and refund of the entry fee before the entry deadline, a full refund, less the non-refundable processing fee, will normally be made. No refunds of registration fees will normally be made after the entry deadline.

ASME may decline to refund any or all entry fees in the case of (1) cancellation of the competition for reasons beyond its own control, (2) non-receipt of the full entry fee by the final entry deadline, or (3) submittal of an entry by an ineligible school.

- J) *Notification of Acceptance* Notification of acceptance will be sent within one week of receipt of the final Entry Date.
- K) *Competition Information* The following information, or a URL for a website that contains this information, shall be provided to each approved entrant at the time of notification of acceptance:
- A vehicle number
 - On-site registration location and time
 - A map showing the location of the various events
 - A schedule of events
 - Location and time for the Design event
 - A course map for the Sprint or the Drag Race event, as appropriate
 - A course map for the Endurance event
- L) *On-Site Registration* All competitors must register on-site with ASME staff before participating in the competition. Registration location and time shall be provided to teams at the time of acceptance, or on the competition website.

During the on-site registration process teams may:

- Request changes in the team roster for verification
 - Receive identification for each team driver (arm stamp, wrist bracelet, etc.)
 - Receive two decals to display their assigned vehicle numbers and ASME logo
 - Receive a final schedule, including times, locations and other event information.
- M) *Late registration* Late registration will only be possible if prior arrangements have been made with ASME, at least one week in advance of the competition start date.

V. Qualification

- A) *Objective* Teams have to demonstrate both their understanding of the rules and their capacity to develop a competitive entry prior to the main HPVC event.
- B) *Description* Teams must submit a 4 page maximum written proposal which communicates the team's capacity in the following areas. Figures that support the proposal may be placed in the appendices and referenced in the text. Appendices will not be counted in the 4 page limit but all supporting text will count against the page limit.
- 1) *Design plan* Describe your team's preliminary vehicle design and innovative design features? Use figures to clearly demonstrate your plans.
 - 2) *Testing plan* Describe the testing that your team plans to do. What numerical and physical testing do you plan to do and how?
 - 3) *Design and fabrication facilities* Teams should discuss their capacity to design and fabricate a vehicle appropriate for competition. Availability of instruction, advising, and facilities for the basic fabrication processes should be highlighted. In the event that such facilities are sub-standard, the team should discuss alternative solutions or outside manufacturing resources which may be utilized.
 - 4) *Institutional and financial support* It is important for teams to have the support of their home institution at an appropriate level (i.e. President, Dean, Department Head, Instructor). Teams must provide evidence of institutional support through a signed letter stating the levels of support clearly. Also, discuss sources and levels of financial support (e.g. institutional, personal, local business) and how it will allow your team to complete its objectives.
 - 5) *Timeline and planning* Proper planning of the various stages of the design, fabrication, and testing process are critical for a teams' success. Communicate this plan such that it is clear that your team will have a fully-built and thoroughly-tested entry prior to the competition. The use of a Gantt chart or project schedule may be beneficial.
 - 6) *Prior experience with HPVC* Prior participation is not a requirement for qualification. However, teams may wish to discuss how lessons learned from their previous experience with HPVC will enable them to be more successful in the present competition. This is the last page that counts towards page limit.
- C) *Submission Deadline* The submission deadline will be posted on the event website. **Qualification proposals must be submitted before the deadline and late submissions will not be accepted.** Failure to submit a proposal before the deadline will result in not being allowed to register for the competition.
- D) *Notification of Qualification Results* The judges will review the qualification submissions based on the criteria listed above, and will extend a formal invitation to successful entries by a date to be posted on the event website.

- E) *Non-participation* All teams must participate in the qualification process in order to compete in event.
- F) *Number of submission per school* There will be no restriction to the number of qualification proposals submitted per school. There will be a restriction of the top three 3 scoring teams per school during qualification allowed to participate in the competition.
- G) *Unique Proposals* Each team must submit a unique proposal. Multiple teams per university are allowed to submit proposals but the content of each one should be unique. Content that is duplicated from another proposal will not be counted for points for both teams.
- H) *Scoring* Scoring of proposals will be done using the rubric in Table 1. A score greater than 0 must be met in order to qualify for participation in the competition. All proposals will be reviewed by multiply judges and their scores will be averaged to calculate the final score.

Table 1: Qualification proposal scoring rubric

Demonstration of meeting the criteria	Points per criteria
Exceptional	4
Strong	3
Competent	2
Unsatisfactorily	1
Did not address the criteria	0

Criteria	Points Possible
Design plan	4
Testing plan	4
Design and fabrication facilities	4
Institutional and financial support	4
Timeline and planning	4
Total Points Possible:	20
Prior experience with HPVC	0

VI. Design Event

- A) *Objective* To demonstrate the effective application of established principles and practices of design engineering to the development of the team's vehicle.
- B) *Description* The Design Event includes three parts:
- Design report submitted in advance of the competition
 - Design presentation to the Judging Team
 - Safety and static inspection by the Judging Team

Failure to submit a design report will result in a team not being scheduled for a presentation. If a team fails to complete any part of the design event, their vehicle will be judged as a non-participant. This condition will not affect the vehicle's participation in the other events, provided that the vehicle successfully completes the safety inspection.

- C) *Design Report* The report should concisely describe the vehicle design and document the design, analysis, and testing processes and results. The report should have the character of a professional engineering report and **should be organized as described in Section VI D).**

Reports should emphasize clarity both in presentation and in the statement of results and conclusions. Photographs and drawings are encouraged where beneficial in documenting unique features of the design.

The design report must clearly display the vehicle number on the cover page.

Design reports shall use 12 point Times Roman font, single line spacing within paragraphs and double line spacing between paragraphs. Major headers shall be 14 point Times Roman Bold, left justified. Margins shall be 1 inch top, bottom, left, and right. All figures and tables shall include a caption in 10 point Times Roman italic font. Avoid watermarks and graphics that obscure text legibility.

Report writers should note that bulk is not a desirable feature; therefore, reports have a **30 page maximum limit**. (The limit includes the following sections: Design, Analysis, Testing, Safety, Aesthetics, and Conclusion. Required Form 6, the 3-view drawing, the abstract, and references will not be included in the page count. Penalties will be levied for exceeding the page limit (See Section VI M)). Additionally, judges will not consider any page beyond the 30th.

A copy of the judges score sheet is included in Appendix 2 of these rules. Teams are strongly encouraged to carefully read the score sheet prior to writing the design report.

Teams are expected to comply with ASME's Code of Ethics in the creation of their reports.

D) *Design Report Organization* The design report shall be organized as follows:

- | | | |
|-------|---|---|
| I. | ASME Form 6 | No page number |
| II. | Title Page | No page number |
| III. | 3-View Drawing of Vehicle | No page number |
| IV. | Abstract | Page i |
| V. | Table of Contents | Page ii |
| VI. | Design | Page 1, First page that counts towards limit. |
| | a. Objective | |
| | b. Background | |
| | c. Prior Work | |
| | d. Design Specifications | |
| | e. Concept Development and Selection Methods | |
| | f. Innovation | |
| VII. | Analysis | |
| | a. RPS Analyses | |
| | b. Structural Analyses | |
| | c. Aerodynamic Analyses | |
| | d. Cost Analyses | |
| | e. Other Analyses | |
| VIII. | Testing | |
| | a. RPS Testing | |
| | b. Developmental Testing | |
| | c. Performance Testing | |
| IX. | Safety | |
| | a. Design for Safety | |
| | b. Hazard Analyses | |
| X. | Conclusion | |
| | a. Comparison – Design goals, analysis, and testing | |
| | b. Evaluation | |
| | c. Recommendations | Last numbered page, Last page that counts towards limit. |
| XI. | References | |

E) *Design Report Content* Content of each section should be in accordance with the design report score sheet (see Appendix 2).

- a. ASME Form 6 The first page should be the completed Form 6, available on the Official HPVC Website.
- b. Title Page The title page should include the report title, vehicle number (assigned by ASME), Names of team members including contact information for two designated team members, and the name and contact information of faculty advisor.
- c. 3-View Drawing of Vehicle Include a drawing of the complete vehicle with at least front, top, and side projections. Key dimensions such as wheelbase, track, overall length and

overall width should be included. Drawings to follow ASME Y14.5 and related standards such as ASME Y14.24 and ASME Y14.3 .

- d. Abstract The abstract should give a clear summary of the objectives, scope, and results of the vehicle design. It should be limited to no more than 300 words.
- e. Design The Design section should include an overall description of the vehicle with appropriate background information, design objectives, design criteria, and design alternatives that were considered. It should clearly demonstrate that established design methodologies, including structured design methods and engineering principles, were effectively used during the vehicle design process. Sub-sections include:

Objectives Clearly state the objectives and design mission of the vehicle

Background Include supporting research and review of prior art. Provide background information to justify your objectives, mission, design approaches, and design concepts. Background research should include specific information found/used to aid in design and development of the HPVC, but should not include your teams general competition history. Appropriate background research can include information found on HPV development, aerodynamics, HPV standards (such as ISO or Federal), competitive vehicles, etc. Cite references as appropriate.

Prior Work Clearly document any design, fabrication, or testing that was not completed in the current academic year. If teams reuse work from previous years and it is not listed here teams will be assessed a penalty for reusing content.

Design Specifications Provide the design specifications for the vehicle. Tables and bullets may be used. Also provide rationale or justification for the specifications as appropriate. Document methods (such as QFD) used to develop the specifications.

Concept Development and Selection Methods Document the use of established concept development and selection tools such as the Pugh's Concept Selection Technique, etc.

Innovation Describe aspects of the vehicle design that are particularly innovative.

Description Describe the final vehicle design, making generous use of drawings and figures. Describe how the vehicle can be practically used, what environmental conditions (weather, etc.) were addressed and how components and systems were selected or designed to meet the stated objectives.

- f. Analysis The analysis section summarizes the engineering evaluation of the vehicle's performance and structural viability as related to the design criteria outlined in the description. **For each analysis documented, the objective, modeling method & assumptions, results, and conclusions should be clearly indicated.** Conclusions should describe how the results were used to improve the vehicle, i.e. what changes were made as a result of the analysis.

Each sub-section should include a table summarizing all analyses completed in that section. The summary should include objectives, methods, and results. In addition, provide selected examples of specific analyses in sufficient depth to allow judges to evaluate the technical correctness of the analysis. The analysis section should include the following sub-sections

RPS Analyses Document the structural analysis of the rollover and side protection system. This section must convincingly demonstrate that the RPS is fully compliant with Section III C) of these rules in order to obtain full points.

Structural Analyses Document structural analyses conducted on the frame or mechanical components. Specify objectives, load cases, methods, and results. FEA is an appropriate tool, but not the only tool, used for structural analyses.

Aerodynamic Analyses Document aerodynamic analyses, including drag estimates, conducted on fairings, aerodynamic devices, or other components. CFD is an appropriate tool for aerodynamic analyses.

Cost Analysis Provide an estimate of production costs for the vehicle. Include a production cost estimate for the vehicle (1) as presented for the competition and (2) as estimated for a production run based on 10 vehicles per month. The production run cost estimate should include capital investment, tooling, parts and materials, labor, and overhead for a three (3) year production run.

Other Analyses Document other analyses conducted during the design process, including power/speed modeling, vehicle handling, stability, steering, suspension kinematics and dynamics, optimizations, etc.

- g. Testing The testing section documents physical tests and/or experiments conducted to develop or verify the design. **For each test, the objectives, methods, results, statistical analysis of data, conclusions, design modifications, and comparisons to product design specifications should be clearly described to acquire full points.** Test results should be compared with design specifications and analytical predictions and should document design changes/validations driven by said results. Sufficient examples should be included to demonstrate the extent to which physical testing was used during the design process. This section should include the following sub-sections:

RPS Testing Physical testing of the RPS system should be documented, including methods, results, and conclusions. This is the testing of the entire RPS and not just the roll bar. Teams must treat the entire system from the rider to the ground as the RPS to achieve full points. This includes the seat, safety harness, attachment hardware, and roll bar.

Developmental Testing Document physical testing conducted to develop or optimize the vehicle design. This testing is usually done early in the design phase to aid in the design process. Include objective, methods, results, and conclusions. Examples of developmental

testing include, but are not limited to testing weld quality, composite materials, RPS mock up, and prototype sub systems.

Performance Testing Document physical testing done to verify vehicle performance. This testing must be conducted on the final version of the HPV or a prototype with similar properties of the system being tested. Include objectives, methods, results, and conclusions. Examples of performance testing include, but are not limited to testing final vehicle performance capabilities, final frame geometry on prototype frame, and aerodynamic testing on finished fairing.

- h. Safety The safety section includes an analysis of potential hazards and **how the team addressed safety** of the 1) vehicle occupants, 2) bystanders, and 3) vehicle builders during the construction of the vehicle (i.e. shop safety).

Features, components, and systems designed to mitigate hazards should be described. Of particular interest is how established engineering principles were used to design safety systems. Teams must also address how they design to protect the riders head and appendages such that they do not contact the ground in the event of a crash where the vehicle falls over or inverts.

At the time of safety inspection teams must have a functioning bell/horn, headlight, taillight, side reflectors, and rearview mirror(s) in order to achieve points for safety accessories.

- i. Conclusions Demonstrate that the design team completed a substantive evaluation of the vehicle design. This section should include the following subsections:

Comparison Use a table to compare the vehicle design specifications with analytical performance predictions and experimental results. Were design objectives met?

Evaluation Describe how the final vehicle was evaluated with respect to the objectives and design specifications.

Recommendations Document any recommendations for future work on the vehicle, including but not limited to modifications and improvements.

- F) **Prior Work** **Design credit will only be given for work done during the current academic year.** The report should clearly indicate if the documented design work is for a new vehicle design or improvements to a previous design. To be considered a new design, the vehicle must be substantially different from previous or additional entries (in the event a school is submitting multiple entireties into a single competition) by that team or school. A substantially different vehicle has a significantly different objective, or has a significantly different design solution. It is acceptable to advance and refine the design of an existing vehicle, but the new developments must be clearly differentiated from prior work. In the event that the design is not a completely new design, the report must clearly identify which features of the design are new and what new analyses, tests, etc., were performed to verify the design changes. Scoring is based solely on the current year's work and design points will not be awarded for design work done in previous

academic years. Unoriginal content, including content generated from previous years and not cited, may be assessed a penalty for plagiarism.

- G) *Design Report Submittal* The design report must be submitted electronically to ASME no later than the report due date. The report due date is normally 32 days prior to the competition and will be announced by ASME well in advance. See the competition website for dates and instructions specific to each competition.
- H) *Late Reports* Design reports will be accepted up to 25 days past the published Report Date, subject to a 4% penalty per day the report is late. Teams that do not submit reports within 25 days after the Report Date will not be eligible for participation in the design event.
- I) *Design Presentation* Teams are to present any design updates since the submission of the design report, and critical design features of their design during the presentation. The presentation will take place in an auditorium and all teams are encouraged to spectate any presentations that they choose.

Design presentations will be done formally and will be combined with the Innovation presentation resulting in a single presentation with a maximum time limit of 12 minutes, and then followed by a maximum of 3 minutes of questions from the judges. Teams can chose to split up time between the Design presentation and the Innovation presentation as they like, but teams must begin with the Design presentation and note clearly when they will switch topics to the Innovation presentation. Though these presentations happen back to back teams will be earning points for two separate events and must clearly delineate when they are presenting on each topic for maximum points to be achieved in each event. Typically four teams will be assigned to each one hour time block and teams must be present at the beginning of their assigned 1 hour block in order to avoid penalties.

Supporting material is encouraged, and PowerPoint or PDF presentations are preferred. Other acceptable media include posters, photographs, charts and other visuals. Live video links to short videos, photographs, data, and other digital visual media will be allowed, but teams are required to imbed it in a PowerPoint or PDF as internet access may not be available. If technology limitations are imposed by the limitations of a specific venue it will be clearly noted on the event page under the ASME HPVC website.

- J) *Static Judging* Vehicles will be statically inspected prior to the start of the safety inspection.

Vehicles will be visually inspected based upon the following items:

- Physical characteristics
- Design features
- Safety features
- Consistency with report
- Safety
- Aesthetics

- K) *Vehicle Display* A designated time block will be set aside for a required public static display of the competing vehicles. At least one team member must be present with the vehicle at all times. During the static display time, it is expected that other participants, spectators and the competition officials will tour the display area. The judges may also review the display and inspect the design features of any vehicles for which a design report was not received.
- L) *Design Scoring* Design scoring is based on the extent to which established engineering design principles were applied in the design process and effectiveness of those design practices used. Scores should also reflect the effectiveness of the report and presentation in communicating the design process and solution. Design teams must address each of the specified topics in order to receive a score for that topic. Design scoring for all vehicles shall be as follows in Table 2.

Table 2: Design event scoring rubric

<u>Subject Area</u>	<u>Points</u>
General	5
Design	15
Analysis	25
Testing	25
Safety	20
Aesthetics	10
Total	100

- M) *Design Score Penalties* In addition to those previously described, penalties may be imposed by the Judging Team for failures to comply with the rules of the Design Event. Penalties will be assessed according to the following table in cases where an unfair advantage might have been gained or the Judges' ability to evaluate a design has been compromised.

<u>Rules Infraction</u>	<u>Maximum Penalty</u>
Report content largely non-original	Event Disqualification
Late report submittal	4% per day
Late for Static Judging or Safety Check	10%
Over Page Limit ("non-participant at 30 pgs over)	3% Per Page
Report does not conform to required outline	10%

- N) *Overall Design Scoring* The judges will compile the design scores including any penalties on a total points basis. The event score is given by

$$\text{Points} = \left(\frac{\text{Team Design Score}}{\text{Maximum Possible Design Score}} \right) \times \text{Maximum Event Points}$$

Where the Maximum Possible Design Score is the maximum points possible according to the Judge's Score Sheet, and the Maximum Event Points are given in Section X.

VII. Speed Event (Sprint or Drag Race)

The competition will include either a sprint or a drag race format. The type of race will be determined and announced well in advance of the competition at the discretion of the Judging Team and host school.

Please note, during the speed event **no outside assistance may be given to the driver(s) of any HPV.**

A. *Sprint Race*

A) *Objective* To provide teams the opportunity to demonstrate the top speed of their vehicles.

B) *Description* The Sprint Event is an individual, timed event with a flying start to achieve top speed on a closed course. Each team shall include multiple drivers with separate scoring categories for both genders.

C) *Sprint Course Description* The course will consist of a straight, smooth, and level (less than 1% slope over entire course) paved surface of suitable width and clear of obstacles, pits, cracks, or potholes. The timed portion of the course shall be 100 meters in length, preceded by a 400 to 600 meter "run-up" section and followed by a "run-down" section at least 200 meters in length. Where possible, the length of the "run-up" should be maximized.

The beginning of the run-up shall be marked by a starting line. All vehicles in line for a run shall remain in a marked staging area until directed by the start line official to move to the starting line. The course will include a separate route for returning vehicles from the "run down" end of the course to the starting area.

While the course should be designed to completely avoid collision hazards, this may not be possible in all cases. Hay bales or equivalent cushioning material will be used to protect vehicles and drivers from collision with any fixed obstacles located adjacent to the course. Such cushioning shall reflect proper safety design with due consideration to the estimated speed of passing vehicles and their direction along the course.

The course shall be clearly marked to indicate the following points:

- Staging area
- Starting line
- Release line
- 300 meters to time trap
- 200 meters to time trap
- 100 meters to time trap
- 50 meters to time trap
- Beginning of time trap
- End of time trap
- End of course

As an alternative venue, a velodrome may be utilized to hold the sprint race. No distance markings will be used in the event of a velodrome race, but the 400 to 600 meter "run-up", 100

meter time trap, and 200 meter “run-down” lengths will be maintained when possible. Timing equipment and the starting line will be limited to the flat straight portions of the velodrome when possible.

- D) *Timing Area* The timing and scoring area, located at the end of the speed trap, will be off limits to spectators and all others except the competition officials and the event timing staff.
- E) *Tally Board* Vehicle speeds and standings shall be posted in a timely manner on a "tally board" or display for the benefit of competitors. The "tally board" will be separated from the timing area.
- F) *Drivers' Meeting* All drivers who will participate in the Sprint Event must attend the mandatory Drivers' Meeting at approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.

By the time of the meeting all team equipment, vehicles and other required items should be in place and clear of the track. Any team that is not represented at this meeting will not normally be permitted to participate in the event; in cases of unavoidable absence, the team may file an appeal with the Judging Team, whose decision regarding participation will be final.

- G) *Starting Order* The first round of sprint attempts will be assigned at random. Subsequent starts will be on a "first ready, first started" basis. Place holding in line is prohibited: a team is not considered ready unless both driver and vehicle are present and prepared to race. Teams will be notified of their staging order prior to the start.
- H) *Line Position Forfeiture* Each successive vehicle will have 15 seconds to begin a sprint attempt after the start line official has determined that the course is ready and safe for the event to proceed. If a vehicle is not ready within the 15-second period, the vehicle must stand aside for others that are ready to proceed. In extreme cases, the vehicle will forfeit the run and must reenter at the end of the line.
- I) *Start Assistance* Assistance is not permitted. The rider must be completely self-sufficient from the beginning of the run until the vehicle crosses the finish line. As always, assistance is permitted in the event of an emergency, but once assistance is given the run is forfeit.
- J) *Number of Attempts* During the Sprint Event each vehicle will be allowed to make as many runs as time and conditions permit and all vehicles will be provided an equal opportunity to compete.

Although all competitors will have an equal opportunity to compete, there will be no assurance of an equal number of runs for all vehicles. Teams may take advantage of every opportunity to maximize their number of runs, or selectively pass opportunities. Such strategies should consider that foregone opportunities may not be regained.

Teams will be notified of race time remaining at 30 minutes, 15 minutes, and 5 minutes until the end of the race time. No team may make a run after the official end of race time.

K) *Interruption and Termination* The Sprint Event will normally run continuously. However, circumstances such as equipment failures, an emergency or hazardous weather or wind conditions may require a delay or premature termination of the event. Delays or terminations will be determined by the Head Judge with the help of the judging team and the Competition Director.

L) *Scoring* The Sprint Event score for each vehicle is based on the winning time for the event, that is, the fastest time of any vehicle in the event. Points are awarded based on the following formula:

$$\text{Points} = \frac{t_{\text{Winner}}}{t} \times (\text{Maximum Event Points})$$

Where t_{Winner} is the time of the winning vehicle, t is the fastest time of the event for a particular vehicle, and the Maximum Event Points is the point value for the event, specified in Section X.

B. Drag Race

A) *Objective* To provide teams the opportunity to demonstrate the speed and reliability of their vehicles in a tournament format.

B) *Description* The Drag Event is a tournament style race where vehicles compete two at a time to be the first to cross a set finish line, from a standing start.

C) *Duration* The Drag Event ends when all races in the bracket have been completed and the champions have been determined.

D) *Drag Course Description* The drag race course shall consist of a paved level course typically between 350 to 450 meters in length. The course shall be at least six (6) meters wide at all locations. The surface shall be smooth and free of potholes, cracks, and debris. Curves are permitted on the course, which may be a closed loop (although a closed loop is not required).

The course immediately following the start and immediately preceding the finish line shall be straight, unless separate and equal length lanes are provided for each vehicle. If the course is not a closed loop there shall be a return path to the staging area.

E) *Timing Area* The timing and scoring area shall be off limits to competitors, spectators, and all others except competition officials and the event timing staff.

F) *Tally Board* If the race venue can support it, race results shall be posted on a tally board or computer monitor throughout the race. Results should be updated after each individual race, and should indicate the winners' and losers' brackets and race times.

G) *Drivers' Meeting* All drivers who will participate in the Drag Race Event must attend the mandatory drivers' meeting for that event. The drivers' meeting shall take place approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.

- H) *Race Description* The Drag Race Event allows two teams at a time to race each other side by side from stationary at a starting line to a predetermined finish line.

The drag race consists of two phases: qualifying and a double-elimination tournament drag race. All vehicles shall compete in the qualifying race. Select vehicles with the fastest qualifying times shall compete in the drag tournament.

- I) *Qualifying Race* The event shall begin with the qualifying race in the order of vehicle number. The maximum number of vehicles racing in each heat shall be at the discretion of the Head Judge, and will depend on the nature of the course and the available timing equipment (typically two). Each vehicle shall be timed separately. Qualifying race place is based on finish times.
- J) *Female Driver Qualifying Race Bonus* The qualifying race time achieved by female drivers will be divided by a factor of 1.5 when calculating seeding.
- K) *Brackets And Seeding* The top 32 vehicles from the qualifying race will advance to the elimination rounds. If there are less than 32 vehicles, then the tournament shall be modified at the discretion of the Head Judge.

After the first round of eliminations, the event is split into two brackets: the winner's bracket and the loser's bracket. At the end of each round, the losers in the winner's bracket move into the loser's bracket. The losers of the loser's bracket are eliminated from the competition. The championship race determines the winner of the event. In the event that neither championship contestant has two losses after the round, an extra race will determine the winner.

Seeding shall be based on qualifying time. That is, the first race shall take place between the vehicles with the first and last qualifying times, the second race between the second and next to last qualifying places, and so on.

Tournament seeding and sequencing may be modified by the Head Judge to account for event-specific circumstances.

- L) *Drag Race* All races in the drag tournament shall be between two vehicles. Vehicles will be instructed at the starting line of the race by a flagman. When both competitors indicate they are ready the flagman will start the race by waving the flag. No verbal command is required therefore the drivers must be able to clearly see the flagman. There will be a finish line judge (if not a closed loop) who will determine the winner of the race.

Following the completion of the race competitors must return to the staging area for succeeding elimination rounds. Once there teams will be instructed by the staging area coordinator. Event and race sequencing will be determined by the Head Judge and announced at the drivers' meeting.

Disabled vehicles at the start or during the race will have no more than 20 seconds to make repairs or they will forfeit the race. Disabled vehicles must clear the course as rapidly as possible.

- M) *Female Driver Drag Race Bonus* Female drivers will be given a 50% time advantage during the drag race through the use of a head start when racing against male drivers. The head start time will be calculated as 50% of the average of the top fifteen fastest qualifier round times to complete the drag course. The female driver will start riding when the starting line judge waves the flag and the male driver will be held at the line for the time calculated. When a female rider races against a female rider no head start will be given.
- N) *Race Forfeiture* Vehicles must be in line and ready to start in turn. If a vehicle is not ready to start at their turn, they forfeit the race and either move to the loser's bracket or are eliminated from the race. If a vehicle is unable to start within 20 seconds of the start signal it must forfeit the race. Forfeiture in the qualifying race makes the vehicle ineligible to compete in the drag tournament.
- O) *Start Assistance* **Assistance is not permitted.** The rider must be completely self-sufficient from the beginning of the heat until the vehicle crosses the finish line. As always, assistance is permitted in the event of an emergency, but once assistance is given the run is forfeit.
- P) *Interruption and Termination* The Drag Race Event will normally run continuously. However, circumstances such as equipment failures, an emergency, hazardous weather, or wind conditions may require a delay. Delays will be determined by the Head Judge with the help of the Judging Team and the Competition Director. The Drag Race Event will end with the completion of the championship round.
- Q) *Scoring* Scores for teams eliminated in the tournament shall be determined by the round in which the vehicle was eliminated. The place order for all remaining vehicles shall be determined by qualifying speed.

Scoring for teams that qualify in the tournament depends on the round in which they are eliminated from the tournament. See Table 3 for example score breakdown for 32 team tournament.

Table 3 Drag Tournament Scoring

Eliminated in Round:	Elimination Match															
	Champion	62, 63	61	60	59	58	57	56	55	54	53	52	51	50	49	48
Place	1	2	3	4	5	5	7	7	9	9	9	9	13	13	13	13
Points	25	23	21	19	17	17	15.6	15.6	14.2	14.2	14.2	14.2	13	13	13	13

Teams that do not qualify for the tournament will be scored based on time obtained in the qualifying round, in accordance with the following formula:

$$Points = \frac{t_{Fastest\ Non-Qualifying\ Time}}{t} \times (12\ Points)$$

VIII. Innovation Event

A) *Objective*

- 1) To encourage innovation that advances the state of the art in human-powered vehicles.
- 2) To provide teams an opportunity to demonstrate significant innovations.

B) *Description* This event provides teams an opportunity to present a documented functional demonstration of a key innovative feature of the design that advances the technology of human powered vehicles. The innovation may be related to vehicle systems, performance, manufacturing methods, safety or other vehicle areas. Though vehicles may implement as many innovative features on their vehicles as they chose, **only one innovation may be selected to be scored in the innovation event.** Innovation is a process and cannot be executed with a single iteration therefore teams will be awarded significant points for the process of developing their innovation including prototyping and documenting their learnings. Teams provide a detailed description of their innovation in their innovation report which is to be submitted concurrently with the design report. During the Innovation presentation, which will immediately follow the design presentation, teams will demonstrate the effectiveness of the innovation through multimedia and answer the judges' questions. The innovation will be scored on design, concept evaluation (prototyping), learning, and execution.

C) *Definition of Innovation*

- 1) Innovation is the introduction of a previously unknown, unusual, or unfamiliar product, process, material or method, or the alteration of an established product, process, material or method by introducing new elements, forms or processes.
- 2) Innovations related to any aspect of human-powered vehicles are encouraged, including vehicle performance, manufacturing and materials, human physiology, safety, and ergonomics.

D) *Target Innovation Areas* Each year, ASME suggests several target areas for innovation. Teams are encouraged – but not required – to develop innovations in the target areas. Bonus points will be awarded by the judges to teams who clearly are developing inside of the target areas.

1) *Current HPVC Innovation Event Target Areas:*

Area	Description
Cargo Carrying	Carrying cargo in human powered vehicle transportation is often overlooked during initial design, yielding very poor solutions which are not elegant, durable, or functionally ideal. This innovation area challenges teams to develop an innovative cargo carrying design which enables the transportation of a wide variety of good from medical kits to consumer items.
Driver Safety in Traffic	Traffic congestion is more prevalent today more than ever, and beyond being an annoyance, quite often driving on heavy traffic roads is a serious safety risk. In this innovation area teams are challenged to design around areas of driver safety in traffic; this includes personal protection in the event of a collision, vehicle protection in the event of a collision with a motor vehicle (such as a crumple zone), or to protection from hazards in the environment like smog or debris.
Human Transport	Often human powered vehicle drives are required to transport multiple riders. In this innovation area teams are challenged to design an efficient and convenient way to comfortably and safely transport one or more additional people with their HPV. Teams will be required to specify how safety is ensured for passengers.

E) *Report* Teams shall submit an Innovation Report. The Innovation Report is due on the same date as the Design Report, but should be submitted separately as a standalone document. (Note: This report will **not** count toward the 30 page limit for the Design Event.) A copy of the judges score sheet is included in Appendix 3 of these rules. Teams are strongly encouraged to carefully read the score sheet prior to writing the design report. The report should be no more than 3 pages in length, but must include a title slide and should contain the following sections:

- 1) ASME Form 6 No page number
- 2) Title Page No page number
- 3) *Design* **First page that counts towards page limit**
 - (a) Need- Describe the need addressed by this innovation. Why is it significant?
 - (b) New Idea- Students must provide clear evidence that they have thoroughly searched the literature and patents for prior and/or similar work
 - (c) Advancing the Art of HPVs- Students must clearly show that the innovation has benefits, which can be performance, ergonomics, cost, environmental, social, etc.
 - (d) Technology and Concept Feasibility Study- Students must clearly demonstrate that the innovation is feasible, and does not require a violation of the laws of physics or the use of an unavailable process or material. Students must also show that the proposed embodiment of the design is feasible. In other words, the concept will work.

- 4) Concept Evaluation- **Note: To achieve points a prototype must be constructed before constructing the final version. A small scale test, materials testing, subsystem test, or full sized prototype are all acceptable to meet this requirement, but a purely analytical/theoretical analysis will not be accepted.**

- (a) Prototype Evaluation- Does the prototype do what was intended? This is not an evaluation of how well it performs, but a validation of the design concept.
- (b) Benefit Study- Students must provide data to show how effectively the prototype achieved the anticipated benefits in question 3.c
- (c) Unanticipated Benefits- Students must provide data to show how effectively the prototype achieved unanticipated benefits. Often the proposed benefits are not as important as unanticipated benefits.

5) Learnings

- (a) Failures- Students should document what did not work -- concepts that turned out to be infeasible (why?), prototypes that did not work (why), and unanticipated difficulties.
- (b) Learning from Failure- Students should document how failures were used as stepping stones to subsequent successes.
- (c) Negative Aspects of the Design- Students should clearly identify and if possible quantify unanticipated negative aspects -- increased cost, regulatory restrictions, negative environmental aspects, etc.
- (d) References- List all references and patents cited in the literature review

- F) *Presentation* The Innovation presentation shall take place in an auditorium and all teams are encouraged to spectate any presentations that they choose. The Innovation presentation will be done formally and will immediately follow the Design presentation presentations resulting in a single presentation with a maximum time limit of 12 minutes, and then followed by a maximum of 3 minutes of questions from the judges. Teams can chose to split up time between the Design presentation and the Innovation presentation as they like, but teams must begin with the Design presentation and note clearly when they will switch topics to the Innovation presentation. Though these presentations occur back to back teams will be earning points for two separate events and must clearly delineate when they are presenting on each topic for maximum points to be achieved in each event.

Teams will **not** be allowed to bring their vehicles to the presentation room, therefore they must document and present evidence of their innovation in a multimedia presentation. Each team shall provide the judges with the following information:

- Objective of the demonstration
- Need addressed by innovation
- Brief description of innovation, including principles of operation
- Innovation demonstration
- Opportunity for teams to discuss additional design, concept evaluation, learnings, and execution completed after the submission of the innovation report

- G) *Team Check-In* Teams must check in with the judging staff ten minutes prior to the start of their time block. Typically four teams will be assigned to each one hour time block and teams must be present at the beginning of their assigned 1 hour block in order to avoid penalties.

- O) *Innovation Score Penalties* In addition to those previously described, penalties may be imposed by the Judging Team for failures to comply with the rules of the Innovation Event. Penalties will be assessed according to the following table in cases where an unfair advantage might have been gained or the Judges' ability to evaluate a design has been compromised.

<u>Rules Infraction</u>	<u>Maximum Penalty</u>
Report content largely non-original	Event Disqualification
Late report submittal	4% per day
Late for presentation	10%
Over Page Limit	3% Per Page
Report does not conform to required outline	10%

- P) *Scoring* Teams will be scored out of 30 possible points (plus 1 bonus point), based on the following criteria:

- 1) Points are awarded based on the following three areas
 - (a) Design 10 points
 - (b) Concept Evaluation 7 points
 - (c) Learnings 7 points
 - (d) Execution 6 points
 - (e) Bonus 1 points

Scoring breakdowns are detailed in the innovation score sheet document which can be found in Appendix 3 of these rules

- 2) Score in the Innovation Event is the total points earned divided by the total possible points, expressed as a percentage:

$$\text{Points} = \left(\frac{\text{Team Raw Score}}{\text{Maximum Possible Raw Score}} \right) \times \text{Maximum Event Points}$$

Where the Maximum Possible Raw Score is the maximum possible according to the Judge's Score Sheet, and the Maximum Event Points are given in Section X.

IX. Endurance Event

- A) *Objective* To provide teams the ability to demonstrate the functionality, agility, and durability of their vehicles.
- B) *Description* The Endurance Event is a 2.5 hour, timed relay race with multiple laps around a closed course. Each team shall include multiple drivers of both genders.
- C) *Endurance Course* The Endurance Event shall take place on a closed-loop course at least 1.5 kilometers in length.
 - (a) The course shall be continuously paved with occasional patches of rough pavement or gravel typical of a public roadway.

- (b) The course shall include turns in both directions and straight sections designed to demonstrate the advantage of the vehicles' aerodynamic features.
- (c) Up and down grades shall be included if possible, with maximum grades on the course to not exceed 5 % uphill or 7% downhill. The maximum vertical distance climbed in one lap shall not exceed 30 meters.
- (d) The course shall include a paved section with no obstacles that is at least 1.0 kilometers long.
- (e) Individual laps should be approximately two (2) kilometers in length, again to the extent that the event site permits; in no case, however, may the lap length be less than 1.5 kilometer.

D) *Start* The start of the race will be an unassisted LeMans style start

- (a) *Start Area* The start area shall accommodate a LeMans style start that includes a broad, straight section immediately preceding the start line. This area shall be wide enough to ensure a safe start. The start area will include a designated driver start area at least 10 meters away from the vehicles parked in preparation for the start.
- (b) *Start Process* Start of the Endurance Event shall begin with all vehicles parked diagonally on one or both sides of the race course. Drivers will be positioned at least 10 meters from their vehicle with a parcel of groceries positioned in front of the driver or adjacent to the vehicle. At the start signal, all drivers shall pick up the parcel, run to their vehicles, enter and buckle in, and then take off.
- (c) *Cargo* Start will include the pick-up and stowage of a grocery parcel that must be carried until the first grocery stop.
- (d) *Starting Order* Vehicles shall start each endurance race in the order of finish for the sprint or drag race. Vehicles with no sprint or drag race score shall be placed at the end of the starting line-up.
- (e) *Starting Driver* The starting driver may be of either gender and is subject to the minimum, maximum and single ride limits (below). In other words, teams may start the race with their fastest driver regardless of gender, if desired.
- (f) *Single-Gender Teams* Vehicles without drivers of both genders shall be held at the start line for 15 minutes, after which they may proceed with the competition as usual.
- (g) *Mechanical Malfunctions at Start* Any vehicle that requires mechanical assistance at the time of the start must forfeit its starting position and safely exit to the side of the course; it may rejoin the event at the rear of the field of competitors when ready. Repair work that interferes with the safe and orderly start of an event may result in a penalty against the responsible team.
- (h) *Caution* Drivers shall use caution during the start to avoid accidents.

E) *Pits* The course layout must include pit work areas, including safe entry and exit; room for the starting line-up; and a straight run of at least 100 meters between the starting line and the first turn.

- (a) *Pit Location* The pit area shall be located in an area adjacent to the course and shall begin not less than 30 meters and not more than 50 meters after the finish line. The pit area shall be located after, but in relatively close proximity to the start line.

- (b) *Pit Crews* Due to space limitations, no more than eight crew members (excluding drivers) will be allowed in the pit area for each team. Crew members may not be in another team's pit area without permission.
- (c) *Pit Stalls* Prior to the drivers' meeting, teams shall locate their pit stall. All equipment must be placed in the selected pit area prior to the drivers' meeting. During the race, all work in the pit area must take place within the selected pit stall and not in the pit lane. (Failure to observe this rule will result in black flag penalties as described in VII Q.)
- (d) *Right of Way in the Pit Area* Competing vehicles have the right of way on the course and in the pit areas at all times during an event. Vehicles entering the pit area from the course shall have the right-of way over those returning from the pits to the course. Interfering with a competing vehicle in any way may result in a penalty assessment against the responsible team.

F) *Start Assistance* **No assistance shall be provided to any driver except in the pit area (except in emergencies).** This includes, but is not limited to, picking up or launching a fallen vehicle, helping to steady a vehicle, helping the driver to remove a fallen or inoperable vehicle from the course (except in emergencies), giving water to a driver, picking up dropped parcel items, etc. The penalty for receiving assistance will be 500 meters deducted from the total race distance for each occurrence.

In the event that assistance is provided to a vehicle after a fall or accident, if the condition of the rider is questionable a judge or course marshal may hold the vehicle for 60 seconds in lieu of the 500 meter penalty. During the 60 second wait, the judge or marshal shall ascertain that the driver is mentally and physical prepared to continue the race.

Note: This rule does not prohibit team members or spectators from checking on the condition of the rider after an accident. If necessary, assistance may be provided to extract an injured or disabled driver or move a disabled vehicle off the course, but may be subject to the 60 second vehicle hold or 500 meter penalty.

G) *Obstacles* Course obstacles shall include:

- A speed bump typical of a city street speed control device
- A stop sign, requiring a vehicle to come to a complete stop until signaled to proceed by the stop sign judge
- Up/down grades (hills) (if local terrain permits.)
- A tight hairpin turn of approximately 180 degrees with a maximum radius that does not exceed 8 meters. Double hairpin turns are acceptable and encouraged if facilities permit.
- A slalom section consisting of a series of tight turns as shown in Figure 2
- A section of rumble strip which will simulate a washboard road or cobblestone street. This will likely be constructed of 1"x4" boards laying flat running perpendicular to the track on 26" centers and will be wide enough for two lanes of traffic through the obstacle.
- Quick turn. As teams approach the quick turn they will be funneled into a single lane 3m wide. Then each rider will be signaled to turn into a right lane or left lane by the quick turn judge when they reach the opening of the lane change delta. Teams will have to switch to the signaled lane within the 3.5m length of the delta. If teams cannot make the lane change a center 3m wide lane will be provided to allow for vehicles to continue on straight, but taking

this lane or knocking down any cones constitutes a failure of the obstacle. Figure 3 shows the quick turn obstacle.

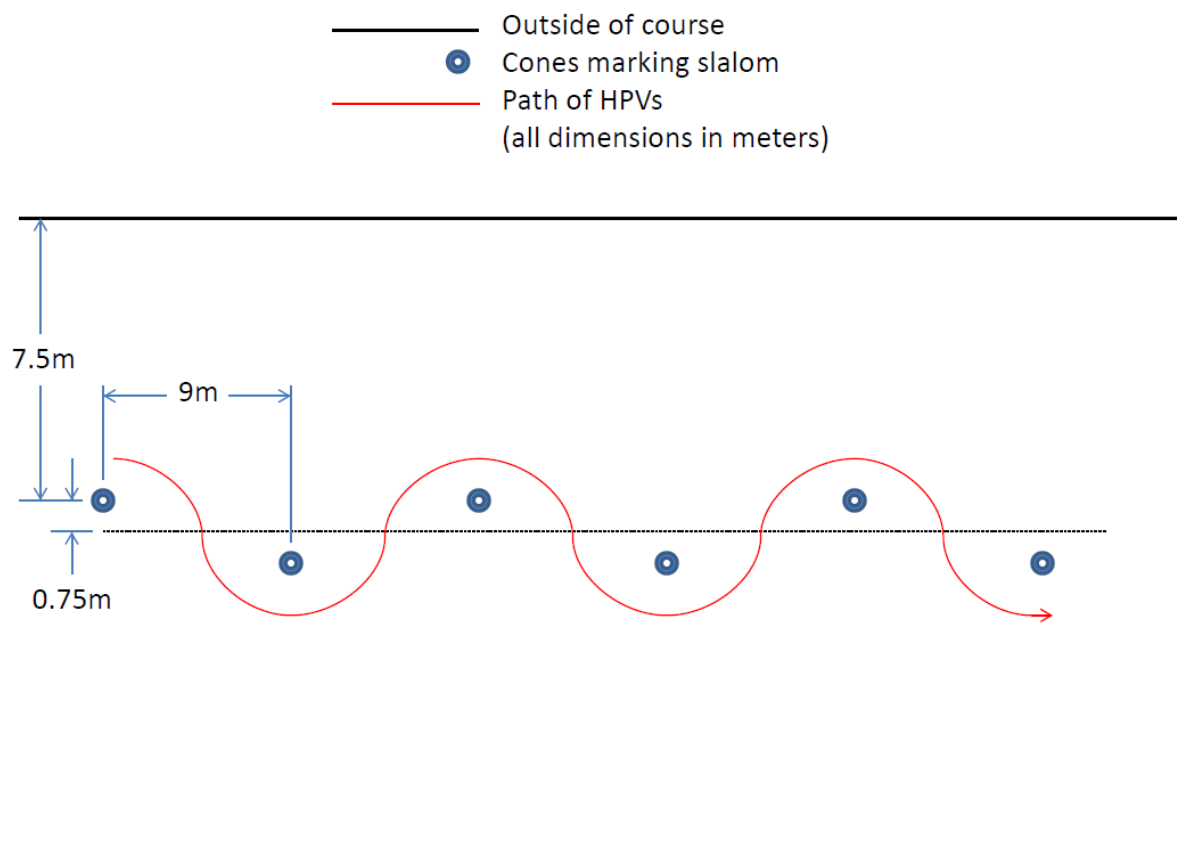


Figure 2: Slalom course (*Note: actual layout subject to limitations of venue*)

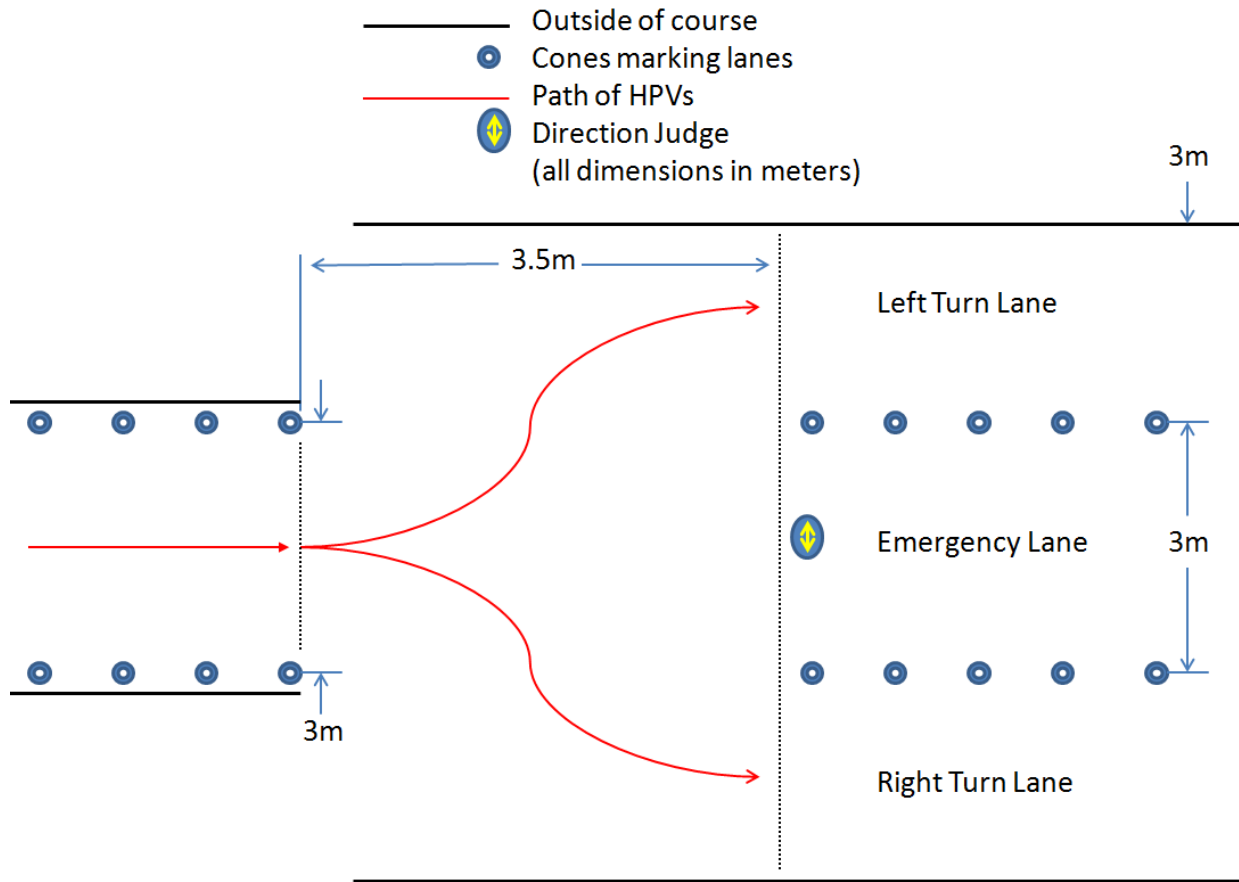


Figure 3: Quick turn obstacle (Note: actual layout subject to limitations of venue)

If possible all obstacles shall be located on the course such that at least one continuous kilometer is obstacle-free, but obstacles will be spread out enough to reduce traffic in and around obstacles if possible. Please note that actual obstacles used at the competitions may differ from described above due to venue limitations.

H) *Parcel Pickup and Delivery* A parcel pickup and delivery station shall be provided on the course. Each team is required to deliver or pick up a parcel five times during the race.

- At least two drivers must make a pickup or delivery.
- Teams start the race with a parcel.
- At the first parcel stop, the initial parcel is deposited with a parcel clerk who will record the time and vehicle number.
- Subsequently, parcels are alternatively picked up or dropped off.
- After dropping the parcel on the fifth stop, the parcel pickup/delivery requirement has been met.

Teams may choose when to stop, and stops are permitted throughout the event. Note that delays due to a waiting queue are possible. Teams are encouraged to plan stops accordingly. Failure to complete five stops with at least two drivers shall result in a one lap penalty for each missed

stop. If all five stops are made by the same driver the team will be penalized one lap. Damage to parcels will be assessed at the completion of the 5 drop offs and appropriate penalties will be made at that time.

When entering the parcel pickup area, vehicles must park in designated parking spots. These spots will be oriented perpendicular to the direction of the course. Drivers must fully dismount their vehicle, retrieve and secure the parcel, and re-mount their vehicle. The orientation of the parking spot will require vehicles to either back into or out of the spot. Note that as always during the endurance race drivers are allowed to push their vehicle. Vehicle entry/exit may not be undertaken in active traffic.

The parcel will be a standard sized 38x33x20 cm (15”h x 13”w x 8”d) reusable grocery bag containing items determined by the host school (mass not to exceed 5.5 kg).

- I) *Lap Counting Process* Laps will be counted by the Judging Team and an Assistant Lap Counter provided by each team.
- (a) The Judging Team will record laps of all teams in sequence as the official record of the race.
 - (b) *Assistant Lap Counters* Each competing team must provide one assistant lap counter as a scoring assistant to count and record laps. This record will serve as a back-up to correlate the official lap count. Lap counters will be provided with a lap counting sheet on which to record:
 - (i) The time-of-day each lap is completed using time from their own watch; counters need not be synchronized between teams
 - (ii) The driver’s gender and identity
 - (iii) The times of driver changes
 - (iv) Any other substantive data

No score will be tabulated for any school that does not provide an assistant lap counter.

- J) *Driver/Stoker Requirements*
- (a) Minimum distance for any driver: the number of laps nearest 5 km or 30 minutes (whichever occurs first)
 - (b) Maximum distance for any driver: the number of laps nearest 20 km.
 - (c) For multi-driver vehicles, the minimum distance also applies to same-gender crews, i.e. at least one male-only crew and one female-only crew must complete the minimum distance. Otherwise, mixed-gender crews are permitted and each individual driver must complete minimum distance. A complete crew swap may not be required however each individual driver must complete the minimum. In the event that the multi driver vehicle may be propelled by a single female this would qualify as a female-only crew.
 - (d) A team may include any number of drivers as long as the distance-per-driver requirements are met.
 - (e) All laps by an individual driver must be continuous – that is, all drivers must complete their laps in sequence, uninterrupted by any other driver, and may not ride in that event further.

- (f) A driver's distance or time may be cut short due to injury, vehicle disablement, or end of scheduled race time. There will be no penalty as a result of scheduled race ending prior to present occupant's completion of minimum distance. Otherwise the Head Judge must rule that the driver is indeed unable to continue in order to avoid penalty.

- K) *Judging Area* The lap counting and judging area will be adjacent to the start/finish area. It will be off limits to everyone except competition officials and the assistant lap counters.
- L) *Drivers' Meeting* All drivers who will participate in the Endurance Event must attend the mandatory Drivers' Meeting for that event. Drivers' meetings will take place approximately 45 minutes prior to the scheduled start of the race. The meeting will clarify operating procedures and signals and will identify course features, hazards, and landmarks.
- M) *Course Practice* The road course will be opened by the Head Judge for practice and will remain open at his/her sole discretion. All vehicles practicing on the course must be operated in a safe manner and with extreme caution, particularly when entering the pit area or any other areas congested with participants, officials, or spectators.

All drivers operating a vehicle on or adjacent to the course, on competing vehicles or otherwise must wear helmets meeting the approved standards for the competition.

- N) *Signals* Flags will be used by competition officials as follows:

Flag Color	Usage
▪ Green	Start event
▪ Red	Stop event
▪ Yellow	Proceed with caution, beware of hazards, no passing without sufficient passing lane
▪ Black	Proceed directly to pits: problem with vehicle, rule infringement, or penalty assessment
▪ White	Less than 10 minutes remaining in the race
▪ Black/white	Event completed, proceed to pit area

Each Course Marshal will be supplied with a yellow flag with which to signal caution in the event of an accident. During a yellow caution flag passing will be allowed when sufficient space is available to pass, but under no circumstances will unsportsmanlike conduct, cutting off another HPV, or contacting another HPV be permitted, and violating this rule will result in a conduct violation.

All other flags will be held in the judging area. As described, a green flag will signal that the event is underway, the black flag is use to indicate that a HPV is to go directly to the pits on their next lap, the white flag indicates 10 minutes left in race time, and the checkered flag indicates the end of the race A red flag displayed at the race start will indicate that a restart is necessary, and all vehicles should proceed by their most direct path to the starting area. A red during the event requires that all vehicles stop at the earliest safe opportunity. At the end of the race a 'clean

up vehicle' will display a red flag to indicate that the race has ended and is not to be overtaken. The vehicles should then return to the pit area as the course will then be closed.

- O) *Disabled Vehicles* The first concern following any accident is the safety of the driver. Once it has been determined that the driver is not injured, disabled vehicles must be removed from the course as soon as possible. In the event of an injury, no person should take any action that might increase the risk associated with the injury. In the case of injury, only on-site paramedics, ambulance workers or licensed medical professionals should tend to the injured.

Disabled vehicles must be removed from the course at the nearest safe exit; drivers may not move disabled vehicles along the course other than to reach a point of removal. Disabled vehicles may be returned to the pit area by the driver and/or team members by safely removing the vehicle from the course and wheeling or carrying it to the pit area.

Course workers will assist with the removal of vehicles from the course, as necessary in the interest of safety. Primary responsibility, however, remains with the respective team. Non-emergency blockage of the course by a disabled vehicle may result in the assessment of a penalty.

Traffic will be controlled in the area of a disabled vehicle by the Course Marshals or by other competition officials, who will oversee the clearing of the course and signal the resumption of normal competition.

Disabled vehicles that have been removed from the course and repaired must reenter the course either at the point of removal or at some point that it had passed between that point and the starting line on that same lap. That is, no vehicle will advance its position on the course as the result of a disablement. Reentering vehicles must yield the right-of-way to vehicles on the course.

- P) *Fouls and Penalties* The Head Judge or the Judging Team will determine whether a foul has occurred and the extent of any assessed penalty (which may include disqualification from the event or from the competition). The responsible team will be notified immediately of an infraction and any resultant penalty by the Judging Team.

Fouls will include—but will not be limited to—the following:

- Failure to meet equipment requirements, including the proper display of vehicle numbers;
- Safety violations, such as entering the course without a proper helmet or seat belt;
- Obstruction of a vehicle by a competing team or by a spectator;
- Foul driving, whether intentional or unintentional;
- Poor sportsmanship or an activity that fosters unfair competition;
- Failure to meet driver lap requirements or limitations.

Drafting is expressly permitted as long as there is no interference with other vehicles.

Penalties will be assessed as follows:

- Equipment violations: Require a pit stop to remedy the violation.

- Safety violations: Subtraction of one or more laps from the team's total lap count.
- Lap requirement violations: deduction of one lap for each improper lap.
- Illegal start assistance on course: Deduction of 500 meters from total distance
- Damaging or loss of parcel: Deduction of a maximum of 500 meters from total distance depending on severity of damage
- Failure to stop at stop sign, complete the slalom, hairpin turn, or quick turn: Deduction of 500 meters from total distance
- Conduct violations:
 - First violation: A minimum of a 15-second delay in the pit area. No work may be performed and no driver changes may be made during this stop.
 - Second violation: A minimum of a 60-second delay, with the same stipulations;
 - Third violation: Disqualification

Violations and penalties will be at the sole discretion of the Head Judge and the Judging Team. Penalty appeals may be filed in accordance with specified protest procedures.

- Q) *Interruptions* The Endurance Event will normally run continuously. However, obstruction of the course, an emergency, hazardous weather, or other conditions may require a delay or premature termination of the event. The need for—and extent of—any such delay or termination will be evaluated by the Judging Team, with the Head Judge making the final determination.

If the event is interrupted and a restart is required, the restart order will recreate, as nearly as possible, the order of vehicles at the time of the interruption.

- R) *Termination* The endurance event shall be run for 2.5 hours. At that time, all vehicles still in the competition will be permitted to finish the lap they are currently on. A "sweep" vehicle will enter the course and complete one lap. The sweep vehicle shall not pass any operable competing vehicles on the course, nor shall any competing vehicles pass the sweep vehicle. At the completion of the lap by the sweep vehicle, the event will be declared complete.

When the official race clock reads 2:20, the white flag shall be placed on prominent display near the judge's area, and will remain there until a race time of 2:30. At that time, the white flag shall be replaced with the black and white checkered flag.

- S) *Female Driver Bonus* The number of laps completed by female drivers will be multiplied by a factor of 1.5.
- T) *Scoring* Vehicle rank in the endurance event is based on average speed minus penalties. The formula for average speed is:

$$V_{average} = \frac{(Number\ of\ Laps\ Completed - Lap\ Penalties) \times (Lap\ Length) - (Distance\ Penalties)}{(Finish\ Time + Time\ Penalties)}$$

Points are awarded based on each individual vehicle's average speed compared to the fastest average speed.

$$Points = \frac{V_{average}}{V_{maximum\ average}} \times Maximum\ Event\ Points$$

Where the Maximum Event Points is the point value for the event, specified in section VIII.

X. Overall Scoring

Overall Score Scores from Design Event, Speed Event and Endurance Events scores will be combined to determine the overall standing of the competition.

The formula for combining the scores is:

$$\text{Overall Score} = \sum \text{Event Scores}$$

The maximum event points are:

Competition Event	Maximum Points
Design Event	30
Speed Event	25
Innovation Event	20
Endurance Event	25
Total Score	100

In the case of a tie in the overall point count, the order of finish in the Design Event will determine the overall finish for all vehicles.

XI. Announcement of Results and Awards

A) *Announcement of Results* The judges will post the results of each event of the competition as soon as possible after the completion of the respective event and validation of the collected data.

B) *Presentation of Awards* The awards presentation will be held after the completion of the competition's final event.

C) *Competition Awards* Competition awards shall be given as follows:

Overall 1st Place:	Trophy and cash prize
Overall 2nd Place:	Trophy and cash prize
Overall 3rd Place:	Trophy and cash prize

Design Event	1st + cash prize, 2nd and 3rd place trophies
Speed Event	1st + cash prize, 2nd and 3rd place trophies
Innovation Event	1st + cash prize, 2nd and 3rd place trophies
Endurance Event	1st + cash prize, 2nd and 3rd place trophies

Overall winner must participate, complete minimum requirements and score points in all events to be eligible for monetary awards.

Minimum requirements are valid non-zero scores in the design event, sprint or drag event, technology innovation event and endurance event.

- D) *Other Awards* Judges may recognize significant achievements by one or more teams during the course of the Competition. Judges awards may include—but are not limited to the following:
- | | | |
|---------------|---------------------|-------------|
| Sportsmanship | Special Achievement | Team Spirit |
|---------------|---------------------|-------------|

Additional awards may be suggested or provided by the host, the teams involved, or others. Such awards are encouraged in the spirit of the competition; however all such awards must be approved by the ASME Judging Team prior to the event.

Additional special awards may be given out by the ASME team to recognize notable or humorous activity and promote the good natured spirit of the competition. These awards will often be very specific to each competition.

XII. Clarification and Modification of Rules

- A) *Clarification and Modification of the Rules* These rules will be modified by the Competition Judges as necessary to maintain the competition as a challenging and rewarding experience for engineering students. No changes by any party shall be made without the written consent of the Global Chief Judge. Questions or recommended changes should be referred to the Event Head Judge.
- B) *Chief and Head Judges* The Chief Judge and Head Judges of the ASME Human Powered Vehicle Challenge serve a three year term and together maintains the competition rules.

The Global Chief Judge is: Chris Wlezien, Chicago, IL

The East Coast Head Judge is: Brian Jones

The West Coast Head Judge is: Will Hilgenberg

The India Head Judge is: Nathan Taylor

The Latin America Head Judge is: Andres Rondon

Questions about the rules should be posted to the forum here:

HPVC Question Forum: <https://groups.google.com/forum/#!forum/asme-hpvc>

You may also email questions to hpvc@asme.org

XIII. Appendix 1 Registration and Documentation Submittal

The following documentation is required for registration and participation in the ASME Human Powered Vehicle Challenge. The required materials should be submitted to the parties indicated in accordance with the schedule as noted.

Document	HPVC Form	Notes	Date Due
Entry Registration	Form 1	Online	Entry Date
Certification of Eligibility	Form 2	Part of Online Certificate of Eligibility, Acknowledgement of Rules, Waiver of Liability & Permission Release form	Entry Date
Safety Certification	Form 3	Part of Online Certificate of Eligibility, Acknowledgement of Rules, Waiver of Liability & Permission Release form	Entry Date
Safety Ride Log	Form 3a	Must be completed, printed out and submitted to ASME officials at on-site registration Available on the Official HPVC Website.	Registration Date
Safety Exemption Request	Form 4	Submit only if an exemption is requested and submit to Head Judge Available on the Official HPVC Website.	Entry Date
Acknowledgment of Rules	Form 5	Part of Online Certificate of Eligibility, Acknowledgement of Rules, Waiver of Liability & Permission Release form	Entry date
Design Reports		ASME electronic submission	Report Date
Innovation Reports		ASME electronic submission	Report Date
Vehicle Description	Form 6	This is a required document for all teams. Please incorporate it into your Design Report. Available on the Official HPVC Website.	Report Date
Protests	Form 7	Submit to Head Judge only if required Available on the Official HPVC Website.	In accordance with Section II G)
Evaluation	Form 8	Form provided by ASME at the end of the competition	End of competition

Please refer to the ASME HPVC website for dates, registrations fees, and registration instructions.

<https://community.asme.org/hpvc/default.aspx>

XIV. Appendix 2 Design Event Judge's Score Sheet

Design Report Evaluation		100	
General		5	Evaluated based on report
1	Form 6	1	Form 6 completed and attached to front of report (V.F.1)
2	Title Page	1	Title page information correct and complete (V.F.2)
3	3-View Drawing	1.5	3-View drawing, in accordance with ASME Y14.5 and related standards such as ASME Y14.24 and ASME Y14.3
4	Abstract	1.5	Abstract included, correct length, clear, concise, and informative. This should be page 1
Design		15	Evaluated based on report and presentation
1	New Design	2	2 - Teams must demonstrate that the entry is a new design (not just a new frame or fairing) completed during the current academic year, or not HPVC entry for last 2 years 1 - Some new elements (frame, fairing, etc.) or no HPVC entry for last year 0 - Similar to previous year's entry
2	Design Methodology		
	Design Objective	1	Provide clear design objectives and goals for project. (Hint: "To Win" or "To do better than last year" are not acceptable objectives)
	Background research	1	Include supporting research and review of prior art. Provide background information to justify your objectives, mission, design approaches, and design concepts. Background research should include specific information found/used to aid in design and development of the HPVC, but should not include your teams general competition history. Appropriate background research can include information found on HPV development, aerodynamics, HPV standards (such as ISO or Federal), competitive vehicles, etc. Cite references as appropriate.
	Prior Work	1	Clearly document any design, fabrication, or testing that was not completed in the current academic year. If teams reuse work from previous years and it is not listed here teams will be assessed a penalty for reusing content.
	Organizational Timeline	1	Include an organizational timeline or Gantt chart showing project scheduling and completion
	Design Criteria/PDS	1	Provide well established design criteria and product design specifications
	Alternatives and Evaluation	1	Present alternative designs that were considered using concept improvement and selection techniques
	Structured Design Methods	2	Document use of established design methodologies, including, but not limited to QFD, Decision Matrices, etc. How did you choose features of your design with respect to your specifications and requirements?
	Description	1	Describe the final vehicle design, making generous use of drawings and figures. Describe how the vehicle can be practically used, what environmental conditions were addressed and components and systems were selected or designed to meet the objectives.
3	Discretionary Points	4	Discretionary points based on overall thoroughness, quality, accuracy, and approach
Analysis		25	Evaluated based on report and presentation
1	Rollover/Side Protection System		Per RPS requirements
	Top Load Modeling	1	Clearly and accurately describe constraints, idealizations, etc.
	Top Load Results	2	Clearly describe and interpret results, score depends on results and perceived validity of results. Target load is to be applied and deflection value is to be clearly documented as result. 0: Maximum total elastic deflection equal to or greater than 7.6 cm (3.0 in); 1: 6.4 cm (2.5 in); 2: 5.1 cm (2.0 in) or less
	Side Load Modeling	1	Clearly and accurately describe constraints, idealizations, etc.
	Side Load Results	2	Clearly describe and interpret results, score depends on results and perceived validity of results. Target load is to be applied and deflection value is to be clearly documented as result. 0: Maximum total elastic deflection equal to or greater than 6.4 cm (2.5 in); 1: 5.1 cm (2.0 in); 2: 3.8 cm (1.5 in) or less
2	Structural Analytical Calculations		Demonstrated appropriate and correct use of numerical computational tools such as FEA, CFD, etc.
	Objectives	1	Clear objective for the analysis
	Analysis Case Definitions	1	Clearly identify and describe analysis cases, include rationale for each
	Modeling	1	Clearly and accurately describe constraints, idealizations, use of symmetry, etc.
	Results	2	Clearly describe and interpret results

	Design Modifications	1	Demonstrate how results were used to modify and improve the design
3	Aerodynamics		
	Aero Device Incorporated	1	All entries are required to have an aerodynamic device incorporated into their design (make-shift items, false claims, and claims such as reclined rider position contributes to aero will not be granted credit)
	Alternatives Evaluated	1	Must evaluate several alternatives in a trade study
	Chosen Design Substantiated	1	Must substantiate chosen aero device through analysis
4	Cost Analysis		
		1	Tabulated cost summary of prototype included. Include all actual expenditures and income sources, but do not include student labor.
		2	Include production cost estimate, 0-None, 1 - Incomplete or not comprehensive, 2 - Complete & Comprehensive
5	Other Analyses		Vehicle handling, stability, steering, suspension kinematics & dynamics, optimizations, and other analyses
	Objectives	1	Clear objective for the analysis
	Analysis Case Definitions	1	Clearly identify and describe analysis cases, include rationale for each
	Results	1	Clearly describe and interpret results
	Design Modifications	1	Demonstrate how results were used to modify and improve the design
5	Discretionary Points	3	Discretionary points based on overall thoroughness, quality, accuracy, and approach
	Testing	25	Evaluated based on report and presentation
1	Rollover/Side Protection System		Per RPS requirements
	Top Load Testing Setup	1	Test method clearly described, appropriate, and scientific
	Top Load Testing Results	2	Clearly describe and interpret results, score depends on results and perceived validity of results. Increasing load is to be added to RPS until maximum deflection is reached and then load achieved is to be clearly stated as the result. 0: Less than 1780N (400 lbf); 1: 1780-2670N (400-599 lbf); 2: ≥2670N (600 lbf)
	Side Load Testing Setup	1	Test method clearly described, appropriate, and scientific
	Side Load Testing Results	2	Clearly describe and interpret results, score depends on results and perceived validity of results. Increasing load is to be added to RPS until maximum deflection is reached and then load achieved is to be clearly stated as the result. 0: Less than 890N (200 lbf); 1: 890-1330N (200-299 lbf); 2: >1330N (300 lbf)
2	Developmental Testing		Physical testing to develop or verify design, usually conducted prior to final vehicle construction
	Objective & Methodology	1	Clear objective for the experiment. Methodology clearly described, appropriate, and scientific
	Results and Discussion	1	Data is reported and presented clearly, with appropriate discussion (interpretation, error sources, uncertainty, etc.)
	Statistical Analysis	1	Data is analyzed and presented clearly, with appropriate statistical analyses (t-test, ANOVA, regression, etc.) and measures (mean and standard deviation, confidence intervals, p-value, etc.)
	Conclusions	1	Conclusions and recommendations stated clearly. Results should be quantitative where possible and include applicable statistical analyses (mean, standard deviation, student T test, etc.)
	Design Modifications	1	Demonstrate how testing results used to modify or improve the design
	Comparison with PDS and Analysis	1	Test results clearly compared with analysis results and product design specifications
	Comprehensiveness	1	Extent of developmental testing: 0: few experiments/little significance on design, 1: many experiments/significant effect on design
3	Performance Testing		Physical testing (often conducted on final vehicle) to evaluate and optimize performance
	Objective & Methodology	1	Clear objective for the experiment. Methodology clearly described, appropriate, and scientific.
	Results and Discussion	1	Data is reported and presented clearly, with appropriate discussion (interpretation, error sources, uncertainty, etc.)
	Statistical Analysis	1	Data is analyzed and presented clearly, with appropriate statistical analyses (t-test, ANOVA, regression, etc.) and measures (mean and standard deviation, confidence intervals, p-value, etc.)
	Conclusions	1	Conclusions and recommendations stated clearly. Results should be quantitative where possible and include applicable statistical analyses (mean, standard deviation, student T test, etc.)
	Design Modifications	1	Demonstrate how testing results used to modify or improve the design
	Comparison with PDS and Analysis	1	Test results clearly compared with analysis results and product design specifications
	Comprehensiveness	1	Extent of developmental testing: 0: few experiments/little significance on design, 1: many

			experiments/significant effect on design
4	Discretionary Points	5	Discretionary points based on overall thoroughness, quality, accuracy, and approach
	Safety	20	Evaluated based on report and safety inspection
1	Rollover/Side Protection System		
	Installation & Design	2	Rollover/Side protection system installed and functional
	Consistent with RPS rule	2	RPS design and fabrication appears consistent with rules
	Prevents bodily contact with ground	2	RPS must prevent the riders appendages and head from contacting the ground in the event of a crash where the HPVC falls over or inverts
2	Seat belt	2	Seat belt installed correctly and appears to meet rules
3	Steering system	2	No excessive play or looseness, correct installation, apparent stability, etc.
4	Sharp edges, protrusions, pinch points	1	No sharp edges or protrusions on fairing, frame or components. No hazardous pinch points, especially near spoked wheels, chains, sprockets, etc. (Subtract points for serious hazards)
5	Other hazards	1	No other obvious hazards
6	Rider's field of view	1	Rider should have more than 180 degrees of visibility
7	Safety Accessories		
	Bell/Horn	1	Audible signal device installed and operational
	Headlight	1	White headlight installed and operational, visible 150 meters to the front, installed and operational
	Taillight	1	Red Taillight visible 150 meters to the rear, installed and operational
	Side reflectors	1	Amber reflectors on each side of vehicle properly installed
	Rear view mirrors	1	Mirror(s) installed providing the driver with views to the rear of the vehicle
8	Materials of construction	1	Materials of construction and production processes for frame and fairing chosen with safety in mind
9	Manufacturing process	1	Explain safety measures used during the construction of the vehicle
	Aesthetics	10	Evaluated based on state of vehicle at safety inspection
	Overall impression of vehicle	3	Overall impression
	Quality of craftsmanship	3	Craftsmanship (welds, joints, assembly, etc.) is professional and attractive
	Quality of custom parts	2	Team-fabricated and custom parts look professional and of high quality
	Quality of Frame/Fairing Finish	2	Exterior finish and decoration quality is neat, attractive, and professional (frame and/or fairing)

XV. Appendix 3 Innovation Event Judge's Score Sheet

	Item	Question	Points	Discussion	Notes	Evaluation based on
Design	1	What is the need for the proposed innovation?	1	Students must document the target market and need of their specific innovation	All innovations solve problems for specific needs. Please list the embodiment of the need and how this innovation solves the problem.	Report
	2	Is the proposed innovation a new idea?	4	Students must provide clear evidence that they have thoroughly searched the literature and patents for prior and/or similar work.	List/discussion of similar patents, summary of literature review, patent application by students on team are sufficient. Points are only awarded in the first year a team submits a design. Ignorance of an existing design does not warrant allocation of points if the judging team does not feel the innovation is not a new idea.	Report
	3	Does the proposed innovation benefit or advance the state of the art of human-powered vehicles?	2	Students must clearly show that the innovation has benefits, which can be performance, ergonomics, cost, environmental, social, etc.	This can be applicable in the HPVC or to mainstream human powered vehicles.	Report
	4	Is the innovation possible with existing or proposed technology and is this specific proposed execution feasible?	3	Students must clearly demonstrate that the innovation is does not require a violation of the laws of physics or the use of an unavailable process or material. Students must also show that the proposed embodiment of the design is feasible. In other words, the concept will work.		Report
Concept Evaluation	5	Is the prototype functional?	3	Does the prototype do what was intended? This is not an evaluation of how well it performs, but a validation of the design concept.		Report
	6	Are the proposed benefits of the concept realized?	3	Students must provide data to show how effectively the prototype achieved the anticipated benefits in question 3.	This can be executed by testing a mock up, prototype, or even a full scale version	Report
	7	Are there any unanticipated benefits?	1	Students must provide data to show how effectively the prototype achieved unanticipated benefits. Often the proposed benefits are not as important as unanticipated benefits.	Often times during the innovation process unanticipated benefits outweigh the original goals of the design and advance the state of the art significantly.	Report
Learnings	8	How and why did you fail?	2	Students should document what did not work -- concepts that turned out to be infeasible (why?), prototypes that did not work (why), and unanticipated difficulties.	Read Henry Petroski to get an idea of how important failures are in innovation.	Report and Presentation
	9	What was learned from the failures?	3	Students should document how failures were used as stepping stones to subsequent successes.	Most innovations are built on what is learned by failures. In fact, more is learned from failures than from successes.	Report and Presentation
	10	What are the unanticipated negative aspects of the design?	2	Students should clearly identify and if possible quantify unanticipated negative aspects -- increased cost, regulatory restrictions, negative environmental aspects, etc.	Even though benefits are realized, the innovation may not have full value because of some unanticipated negatives.	Report and Presentation

	Item	Question	Points	Discussion	Notes	Evaluation based on
Execution	11	How well does the concept function based on the quality of the design?	3	Students should demonstrate how well the concept performs based on the quality of the design and the quality of physical execution	Well executed designs that function as intended shall receive maximum points, whereas poorly executed concepts with low craftsmanship that do not function shall receive low points.	Presentation
	12	Does the quality of execution reinforce the benefit(s) of the innovation?	3	Students must show that the physical execution of the design allows for or exceeds the intended benefits of the innovation	If the execution of the concept performs up to or beyond the intended level described in the benefits, full points should be awarded. If explicit metrics for measuring the quality of execution are not available the judges will assess points at their discretion.	Presentation
Bonus	13	Did the proposed innovation apply to one of the targeted innovation areas?	1			Report