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RULES FOR THE 2013 HUMAN POWERED VEHICLE CHALLENGE



**Rules for the
2013 Human Powered Vehicle Challenge
ASME**

Table of Contents

I. General Information	6
<i>Objective</i>	<i>6</i>
<i>Superiority of Rules.....</i>	<i>6</i>
<i>Location</i>	<i>6</i>
<i>Schedule Summary & Host Information</i>	<i>6</i>
<i>Competition Summary.....</i>	<i>6</i>
<i>On-Site Schedule.....</i>	<i>6</i>
II. General Rules of Competition	7
<i>Minimum Number of Vehicles to Compete</i>	<i>7</i>
<i>Events of the Competition</i>	<i>7</i>
<i>Energy Storage Device</i>	<i>7</i>
<i>Modification of Vehicles</i>	<i>7</i>
<i>Aerodynamic Devices.....</i>	<i>8</i>
<i>Vehicle Number and Logos.....</i>	<i>8</i>
<i>Fairness of Competition.....</i>	<i>8</i>
<i>Protests</i>	<i>8</i>
<i>Event Scoring</i>	<i>9</i>
III. Safety	9
<i>General</i>	<i>9</i>
<i>Performance Safety Requirements.....</i>	<i>9</i>
<i>Rollover Protection System.....</i>	<i>9</i>
<i>Safety Harness</i>	<i>10</i>
<i>Exemptions.....</i>	<i>12</i>
<i>Vehicle Hazards</i>	<i>12</i>
<i>Clothing and Protective Equipment.....</i>	<i>12</i>
<i>Required Safety Test of Energy Storage Devices.....</i>	<i>12</i>
<i>Safety Certification</i>	<i>13</i>
<i>Safety Inspection and Demonstration</i>	<i>13</i>
<i>Modifications Affecting Safety</i>	<i>13</i>
<i>Disqualification of Unsafe Vehicles.....</i>	<i>13</i>
IV. Entry and Registration.....	13
<i>Team Eligibility.....</i>	<i>13</i>
<i>Team Member Eligibility and Certification.....</i>	<i>13</i>
<i>Verification of Team Rosters</i>	<i>14</i>
<i>Vehicle Design, Analysis, and Construction.....</i>	<i>14</i>
<i>Driver Requirement Exceptions.....</i>	<i>14</i>
<i>Submittal of Final Entries.....</i>	<i>14</i>

<i>Late Entries</i>	15
<i>Entry fees</i>	15
<i>Refund of Entry Fees</i>	15
<i>Notification of Acceptance</i>	15
<i>Competition Information</i>	15
<i>On-Site Registration</i>	15
<i>Late registration</i>	16
V. Design Event	16
<i>Objective</i>	16
<i>Description</i>	16
<i>Time and Place</i>	16
<i>Design Report</i>	16
<i>Design Report Organization</i>	17
<i>Design Report Content</i>	17
<i>Prior Work</i>	20
<i>Design Report Submittal</i>	20
<i>Late Reports</i>	20
<i>Design Report Update</i>	21
<i>Static Judging</i>	21
<i>Vehicle Display</i>	21
<i>Design Scoring</i>	21
<i>Design Score Penalties</i>	22
<i>Overall Design Scoring</i>	22
VI. Speed Event (Sprint or Drag Race)	22
Sprint Race	22
<i>Objective</i>	22
<i>Description</i>	22
<i>Time and Place</i>	23
<i>Duration</i>	23
<i>Sprint Course Description</i>	23
<i>Timing Area</i>	23
<i>Tally Board</i>	24
<i>Drivers' Meeting</i>	24
<i>Starting Order</i>	24
<i>Line Position Forfeiture</i>	24
<i>Start Assistance</i>	24
<i>Number of Attempts</i>	24
<i>Interruption and Termination</i>	25
<i>Scoring</i>	25
Drag Race	25
<i>Objective</i>	25
<i>Description</i>	25
<i>Time and Place</i>	25

<i>Duration</i>	25
<i>Drag Course Description</i>	25
<i>Timing Area</i>	26
<i>Tally Board</i>	26
<i>Drivers' Meeting</i>	26
<i>Race Description</i>	26
<i>Qualifying Race</i>	26
<i>Brackets And Seeding</i>	26
<i>Drag Race</i>	27
<i>Race Forfeiture</i>	27
<i>Start Assistance</i>	27
<i>Interruption and Termination</i>	27
<i>Scoring</i>	27
VII. Innovation Event	28
<i>Objective</i>	28
<i>Description</i>	28
<i>Definition of Innovation</i>	28
<i>Target Innovation Areas</i>	28
<i>Report</i>	29
<i>Time and Place</i>	30
<i>Demonstration Area</i>	30
<i>Demonstration Order and Scheduling</i>	30
<i>Demonstration</i>	30
<i>Energy Storage Devices</i>	30
<i>Judging Area</i>	30
<i>Team Check-in</i>	31
<i>Disabled Vehicles</i>	31
<i>Scoring</i>	31
VIII. Endurance Event	31
<i>Objective</i>	31
<i>Description</i>	31
<i>Time and Place</i>	31
<i>Endurance Course</i>	31
<i>Start</i>	32
<i>Pits</i>	32
<i>Start Assistance</i>	33
<i>Obstacles</i>	33
<i>Parcel Pickup and Delivery</i>	33
<i>Lap Counting Process</i>	34
<i>Driver/Stoker Requirements</i>	34
<i>Judging Area</i>	35
<i>Drivers' Meeting</i>	35
<i>Course Practice</i>	35
<i>Signals</i>	35

<i>Disabled Vehicles</i>	35
<i>Fouls and Penalties</i>	36
<i>Interruptions</i>	37
<i>Termination</i>	37
<i>Scoring</i>	37
IX. Overall Scoring	28
X. Announcement of Results and Awards	38
<i>Announcement of Results</i>	38
<i>Presentation of Awards</i>	38
<i>Competition Awards</i>	38
<i>Other Awards</i>	49
XI. Clarification and Modification of Rules	39
<i>Clarification and Modification of the Rules</i>	39
<i>Chief Judge</i>	39
Appendix I: Registration and Documentation Submittal	40

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 (East and West North America and international) can be found on the official HPVC website. Teams wishing to participate should consult the HPVC website or the ASME HPVC Community on Facebook .

Official HPVC Website: [http://www.asme.org/events/competitions/human-powered-vehicle-challenge-\(hpvc\)](http://www.asme.org/events/competitions/human-powered-vehicle-challenge-(hpvc))

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

- D) *Schedule Summary & Host Information* The ASME HPVC web site 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. The overall competition winner must compete in all four events.
- F) *On-Site Schedule* On-site registration begins on Friday morning of the competition. All teams must register in person before the end of the registration period. Each team will be provided with a static judging/safety inspection time block at registration.

The design event shall consist of static judging by the Judging Team. The design event and a safety inspection will take place throughout the day on Friday. It is the responsibility of each team to be ready at the start of their assigned time block.

The speed event (a sprint or drag race) will take place on Saturday morning. The innovation event will occur on Saturday afternoon, and the endurance race will be held on Sunday morning. Prizes and trophies will be awarded in a ceremony after the endurance event, usually in conjunction with a banquet or meal.

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.

Further, no trophy or prize money will be awarded to the overall winner unless the vehicle completes and scores 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 and static judging of their design.
- Men's and Women's 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. Separate scores for men and women are recorded for this event.
- 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) *Energy Storage Device* Vehicles are encouraged to use energy storage devices. Energy must be stored while the vehicle is in motion, with human power as the sole external source of energy. Prior to each event, 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 may begin the demonstration with stored energy. 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.

D) *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.

- E) *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 Chief Judge.

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

- F) *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.

School Name – All vehicles must display their school name or initials on each side of the vehicle in characters at least 10.1 cm (4 inch) high in a color that contrasts with the background.

If the ASME decal or displayed school name 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.

- G) *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.
- H) *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 Chief 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 HPVC website or from HPVC officials.

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.

- I) *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.

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 Chief 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 (15.5 miles per hour) in a distance of 6.0 m (19.7 feet), can turn within an 8 m (26.2 ft) radius, and demonstrate stability by traveling for 30 m (98.4 feet) in a straight line at a speed of 5 to 8 km/hr (3-5 mph) (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 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 600 lb 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. 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 600 lb, 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 1200 lb.

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 2.0 inches and shall not deform such that contact with the driver's helmet, head or body will occur.

- (b) Side Load: A load of 300 lb per driver/stoker shall be applied horizontally to the side of the roll bar at shoulder height. 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 300 lb, 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 600 lb.

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 1.5 inches 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.

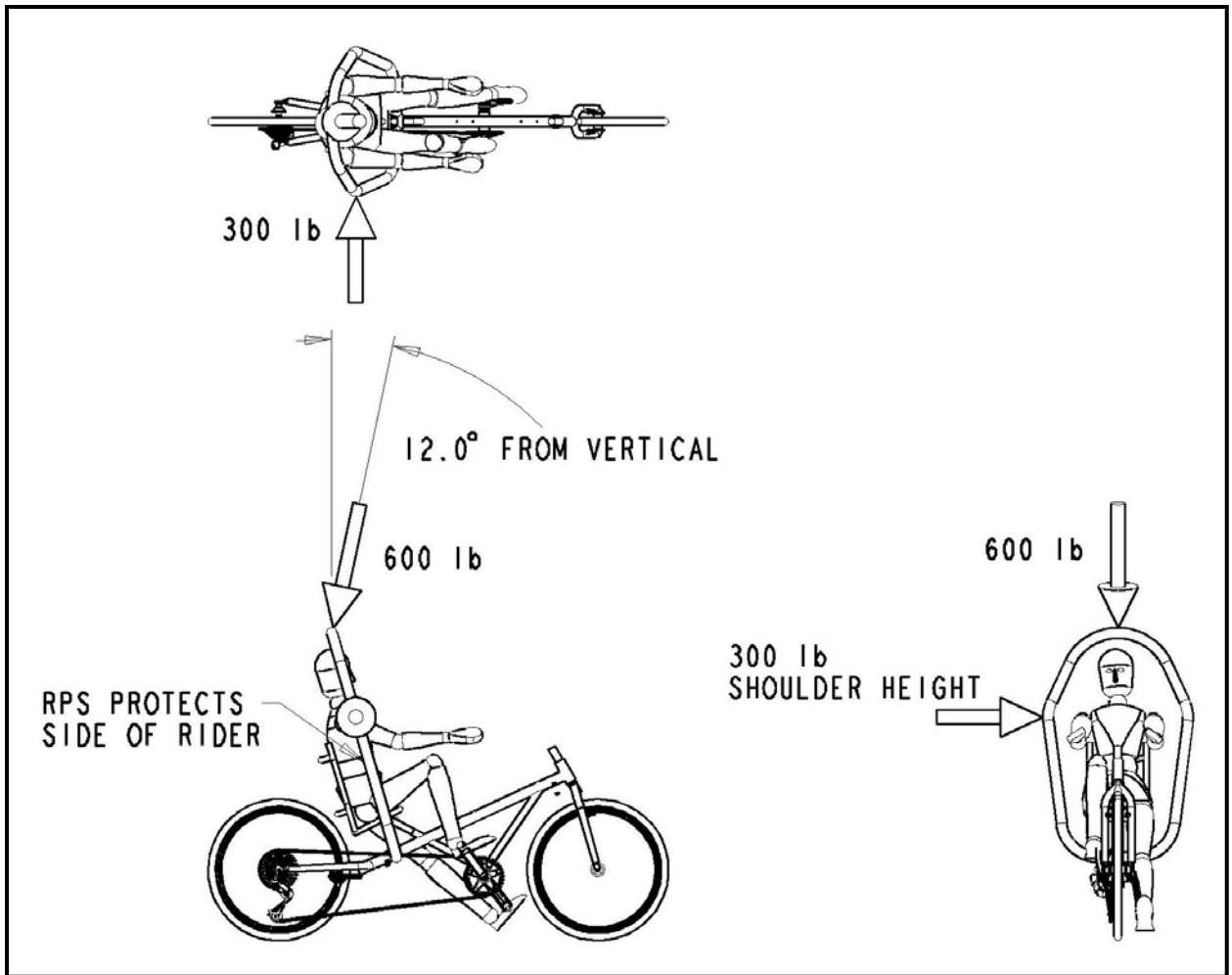


Figure 1: Example of Proper RPS Design and Side and Top Load Case Applications (Note: Loads shown should not be applied concurrently in analysis and/or testing)

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 1" (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 750lb.

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 750lb.

E) *Exemptions* Any team may request an exemption from rule **Section III.C** or **Section III.D** (HPVC Form 4). The request must be based on the safety of the driver or general public, and must be submitted in writing to the Chief 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. The intent of the seat belt rule is to maximize safety, based primarily on the team's evaluation. It allows drivers of partially faired vehicles to operate those vehicles without safety harnesses and rollover protection, but only after a waiver is requested and granted.

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.

G) *Clothing and Protective Equipment* All participants must wear 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, and
- 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 (HPVC Form 3) that:
- 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.
 - 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.
- 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 (within one hour of the end of the Static Judging 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 and 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) *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.
- E) *Driver Requirement Exceptions* All racing events require that teams have at least one complete crew of each gender. Significant penalties are incurred for teams that do not meet this requirement, as described in the rules for each event. An exception to the eligibility rule may be granted to allow drivers to compete for a school other than that in which they are enrolled, as described below. No other exceptions will be allowed.

If a participating school's roster cannot support at least one complete crew of each gender, that school may request the voluntary participation of one or more drivers from volunteers in attendance provided that the volunteer 1) meets all eligibility requirements from rule IV B and 2) will not participate in the same event for any other team. The requester must submit a written request for a waiver of the rules for this purpose to the Chief Judge for approval prior to the start of the applicable event. Scores derived in this manner will be credited to the requester.

- 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 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:

- 1) Design report submitted in advance of the competition
- 2) Static inspection by Judging Team
- 3) Safety inspection by competition official

Failure to submit a design report will result in a team not being scheduled for an inspection. 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) *Time and Place* The Design Event will be held on Friday starting at approximately noon at a location specified by the host organization.

D) *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 V.E).**

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 V. 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.

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

1. ASME Form 6 No page number
2. Title Page No page number
3. 3-View Drawing of Vehicle No page number
4. Abstract Page i
5. Table of Contents Page ii
6. 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
7. Analysis
 - a. RPS Analyses
 - b. Structural Analyses
 - c. Aerodynamic Analyses
 - d. Cost Analyses
 - e. Other Analyses
8. Testing
 - a. RPS Testing
 - b. Developmental Testing
 - c. Performance Testing
9. Safety
 - a. Design for Safety
 - b. Hazard Analyses
10. Aesthetics
11. Conclusion
 - a. Comparison – Design goals, analysis, and testing
 - b. Evaluation
 - c. Recommendations
 - d. Conclusion **Last numbered page, Last page that counts towards limit.**
12. References

Appendix I – Innovation Event Report

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

- 1) ASME Form 6 The first page should be the completed Form 6, available on the HPVC web site.

- 2) 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.
- 3) 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.
- 4) 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.
- 5) 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 Provide background information to justify your objectives, mission, design approaches, and design concepts. Cite references as appropriate.

Prior Work Clearly document any design, fabrication, or testing that was not completed in the current academic year.

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.

- 6) 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 and 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.

- 7) Testing The testing section documents physical tests and/or experiments conducted to develop or verify the design. For each test, the objectives, methods, and results should be clearly described. 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.

Developmental Testing Document physical testing conducted to develop or optimize the vehicle design. Include objective, methods, results, and conclusions.

Performance Testing Document physical testing done to verify vehicle performance. Include objectives, methods, results, and conclusions.

- 8) 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.

- 9) Aesthetics Document how aesthetics was addressed during the design of the vehicle.

- 10) 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.

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.

Conclusion Clearly state your conclusions with respect to the vehicle. Were design objectives met?

- G) *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 entries 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.
- H) *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.
- I) *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.

- J) *Design Report Update* During the static inspection, teams will provide the judges with an update summarizing the accomplishments made since design report submittal. The update is made orally to the judges, and shall not exceed five minutes duration.

Supporting material, though not required, is encouraged, and posters are preferred. Other acceptable mediums also include photographs, charts and other visuals. Live video links to short videos, photographs, and other digital visual media will be allowed, but teams are responsible for their own display equipment.

- K) *Static Judging* Teams will be assigned time blocks to have their vehicles inspected at the on-site registration. Typically six teams will be assigned to each one hour block. Teams must be present with their vehicle at the beginning of their assigned time block in order to avoid penalties.

Teams will have a maximum of 10 minutes to display their vehicle to the judges, including the five minute oral update report.

Vehicles will be visually inspected based upon the following items:

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

Teams should prepare a presentation board (typ. 36 x 48 in) to describe the design and construction of their vehicle and key innovative features.

- L) *Vehicle Display* An area adjacent to the inspection site (see competition website) will be designated for static display of the vehicles. Teams should have the vehicle in the static display area while waiting for their inspection time block, or after completing required inspections. 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.

- M) *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:

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

N) *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.

Rules Infraction	Maximum Penalty
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%

O) *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 Part VIII.

VI 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.

Separate speed events are held for men and women.

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. The male and female sprint races shall be run concurrently.

- C) *Time and Place* The Sprint Event, a "flying start speed trial," will be held on Saturday morning at approximately 8:00 AM at a location specified by the host organization. The exact starting time may vary due to weather conditions or equipment readiness.
- D) *Duration* The Sprint Event will normally continue for four hours. However, this time may be either extended or curtailed as deemed necessary by the Chief Judge.
- E) *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

- F) *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.

- G) *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.
- H) *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.

- I) *Starting Order* The first round of sprint attempts will be in the numerical order of the vehicles to the extent possible. 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.
- J) *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.
- K) *Start Assistance* Start assistance will be limited to holding the competing vehicle upright and stabilizing it as it begins its run; pushing the vehicle is only permitted as required to keep the vehicle stabilized and upright. No more than two individuals may assist in the starting process, and all assistance must end within the first 10m, which will be marked.

If the starting official determines that a vehicle has received start assistance in excess of that allowed by these rules, a mis-start may be declared. The mis-start shall be made known by a single blast of a horn or whistle, or as announced at the Driver's Meeting. This will occur before the vehicle reaches the "300 meters to time trap" marker.

- L) *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.

Under normal conditions, all present and competing teams will be notified before the final run is begun, and all teams will be allowed an opportunity to make a final attempt.

- M) *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 Chief Judge with the help of the judging team and the Competition Director.
- N) *Scoring* The Sprint Event is scored separately for each gender. Thus each vehicle will have two sprint scores: one for male drivers and one for female drivers.

The point 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 VIII.

Drag Race

- O) *Objective* To provide teams the opportunity to demonstrate the speed and reliability of their vehicles in a tournament format.
- P) *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.
- Q) *Time and Place* The Drag Race Event shall be held on Saturday morning at approximately 8:00 AM at a location specified by the host organization. The exact starting time may vary due to weather conditions or equipment readiness.
- R) *Duration* The Drag Event ends when both the Men's and Women's events are complete and champions have been determined. However, this time may be curtailed as deemed necessary by the Chief Judge.
- S) *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.

- T) *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.
- U) *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.
- V) *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.
- W) *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 Event is gender specific. Each driver shall compete against drivers of the same gender. Separate scores shall be kept for male and female drivers.

The drag race consists of two phases: qualifying and a double-elimination tournament drag race. All vehicles shall compete in the qualifying race. The 16 vehicles with the fastest qualifying times shall compete in the drag tournament.

- X) *Qualifying Race* The event shall begin with the female driver qualifying race. After all female drivers have completed the qualifying race, the male qualifying race shall commence. In both male and female races, vehicles shall start in the order of vehicle number. The maximum number of vehicles racing in each heat shall be at the discretion of the Chief 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.
- Y) *Brackets And Seeding* The top 16 vehicles from the qualifying race will advance to the elimination rounds in each gender. If there are less than 16 vehicles, then the tournament shall consist of 8 vehicles.

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 Chief Judge to account for event-specific circumstances.

- Z) *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 Chief 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.

- AA) *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.
- BB) *Start Assistance* Start assistance will be limited to holding the competing vehicle upright and stabilizing it as it begins its run; pushing the vehicle is only permitted as required to keep the vehicle stabilized and upright. No more than two individuals may assist in the starting process, and all assistance must end within the first 10 meters, which will be marked.
- CC) *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 Chief Judge with the help of the Judging Team and the Competition Director. The Drag Race Event will end with the completion of the championship rounds for both genders.
- DD) *Scoring* The top (16) (or 8 in the event of an 8-vehicle tournament) places 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. Separate scores shall be maintained for each gender.

Scoring for teams that qualify in the tournament depends on the round in which they are eliminated from the tournament. See Table 1.

Table 1 Drag Tournament Scoring

		Elimination Match														
Eliminated in Round:	Champion	30, 31	29	28	25	26	25	24	23	22	21	20	19	18	17	16
Place	1	2	3	4	5	5	7	7	9	9	9	9	13	13	13	13
Points	12.5	11.5	10.5	9.5	8.5	8.5	7.8	7.8	7.1	7.1	7.1	7.1	6.5	6.5	6.5	6.5

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:

$$\text{Points} = \frac{t_{\text{Fastest Non-Qualifying Time}}}{t} \times (6.0 \text{ Points})$$

VII 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 complete a functional demonstration of a key innovative feature of the design that advances the technology of human powered vehicles. Innovation may be related to vehicle systems, performance, manufacturing methods, safety or other vehicle areas. Teams provide a detailed description of their innovation in Appendix 1 of the design report. During the Innovation Event, teams will have 5 minutes to demonstrate the effectiveness of the innovation and answer the judges’ questions. The innovation will be scored on capability, innovativeness, and effectiveness.

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 will suggest several target areas for innovation. Teams are encouraged – but not required – to develop innovations in the target areas.

1) 2013 HPVC Innovation Event Target Areas:

Type of Vehicle	Description	Areas
Bicycles	Provide bicycles with zero-speed and low-speed stability, ensuring that a bicycle can come to a full stop or ride at very low speeds without risk of overturning.	Performance and Safety A practical velomobile must be able to stop and start unassisted and without falling.
All	Provide a means for rapid unassisted ingress and egress, including opening/closing door or hatch and securing safety belt or harness.	Performance Ingress/egress ease is important in the endurance event and in the real world.
All	Provide a means of packing a faired recumbent in a case not exceeding 62 linear inches (x+y+z). Several folding production bicycles have this capability, but relatively few recumbents particularly with packable fairing.	Usability (This would be a real boon for international teams and teams that travel great distances.)

E) *Report* Teams shall submit an Innovation Report. The Innovation Report is due on the same date as the Design Report, and should be attached as Appendix 1. (Note: This report will **not** count toward the 30 page limit for the Design Event.) The report should be no more than 3 pages in length, and should contain the following sections:

- 1) *Objective* – Clearly state the objective of the innovation.
- 2) *Need* – Describe the need addressed by this innovation. Why is it significant?
- 3) *Description* – Describe the innovation, including principles of operation, unique elements, and implementation. Be sure to provide clear, but brief, answers to the following questions:
 - (a) How is the state-of-the-art of human-powered vehicles advanced with this innovation?
 - (b) What additional capabilities are provided by this innovation?
 - (c) Is the innovation a new concept or an improvement/new implementation?
 - (d) How does the innovation improve your vehicle?
- 4) *Literature review* – Summarize the results of a literature search to find related work. What similar ideas have been attempted in the past? How is your idea different?
 - (a) *Patent search* – Include a patent search in the literature review.
 - (b) *Patentability* – Based on the literature review, is this innovation patentable?
- 5) *Testing and Evaluation* – Describe how the innovation was tested or evaluated for functionality and for evaluating the benefit of the innovation. Clearly indicate if the innovation functions as intended.
- 6) *Market Analysis* – Include a brief analysis of the marketability of the innovation, considering costs, benefits, markets, and customer acceptance.

- 7) *Conclusions and recommendations* – Provide clear and concise conclusion regarding the capability, novelty, and effectiveness of the innovation. Include recommendations for future development or additional implementations.
- 8) *References* – List all references and patents cited in the literature review.
- F) *Time and Place* The Innovation Event will take place on Saturday, beginning at approximately 1:30 PM at a location specified by the host organization.
- G) *Demonstration Area* The Innovation Event shall take place on a paved area suitable for demonstrating human-powered vehicles. The size, configuration, and grade will be posted on the HPVC website. Any team that cannot demonstrate their innovation within the limits of the published area must contact the chief judge no later than the report due date to arrange for an alternative site or alternative evaluation method.
- H) *Demonstration Order and Scheduling* Teams will demonstrate their innovation in order of vehicle number. Teams will be scheduled in blocks of ten vehicles per hour time block. Teams must check in with the judging team at the beginning of their time block. Any team that is late for check-in will be considered a non-participant.
- I) *Demonstration* When called for a demonstration by the judges, each team shall provide the judges with the following information in addition to a functional demonstration of the innovation:

Objective of the demonstration
 Need addressed by innovation
 Brief description of innovation, including principles of operation
 How is the state-of-the-art advanced with this innovation?
 What additional capabilities are provided by this innovation?
 Is the innovation a new concept or an improvement/new implementation?
 Does the innovation function as designed?
 How does the innovation improve your vehicle?
 Describe how the innovation was tested or evaluated for function and benefit.
 Conclusions and recommendations

Teams proposing innovations that cannot be conveniently demonstrated on-site (such as manufacturing methods, etc.) should provide documented evidence of the effectiveness of the innovative design.

- J) *Energy Storage Devices* Energy storage devices that meet the requirements of II.C may be used in the demonstration and may start the demo with stored energy. Judges shall be advised if stored energy is used during the demonstration.
- K) *Judging Area* The judging area will be adjacent to the demonstration area. It will be off limits to all participants and spectators except the team currently performing a demonstration.

- L) *Team Check-in* Teams must check in with the judging staff ten minutes prior to the start of their time block.
- M) *Disabled Vehicles* In the event of an accident during a demonstration, the first concern is the safety of the driver. Once it has been determined that the driver is not injured, the demonstration may continue if time permits. In the event the vehicle is disabled, it must be removed from the demonstration area by the team in a timely manner. In no event will additional time be granted due to an equipment malfunction or driver error.
- N) *Scoring* Teams will be scored out of 30 possible points, based on the following criteria:
- 1) Points are awarded based on the following three areas

(a) Capability	6 points
(b) Innovation	9 points
(c) Effectiveness	10 points
(d) Judge's Discretion	5 points
 - 2) Vehicle 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 Part IX.

VIII 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) *Time and Place* The Endurance Event will take place on Sunday, beginning at approximately 8:30 AM at a location specified by the host organization.
- D) *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.
- E) *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. 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 women's sprint or women's drag race. Vehicles with no women's 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.
- F) *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 select their pit stalls on a first come first serve basis. 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.
- G) *Start Assistance* No assistance shall be provided to any driver except in the pit area (except in emergencies). This includes picking up or launching a fallen vehicle. 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.

- H) *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 and to hold that stop for at least five (5) seconds**
 - Up/down grades (hills) (if local terrain permits.)
 - A tight hairpin turn of approximately 180 degrees with a 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
 - A section of rough pavement or gravel surface

All obstacles shall be located on the course such that at least one continuous kilometer is obstacle-free.

- I) *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.

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 (weight not to exceed 12 lbs).

- J) *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.

K) *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 Chief Judge must rule that the driver is indeed unable to continue in order to avoid penalty.

L) *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.

M) *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.

N) *Course Practice* The road course will be opened by the Chief 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.

O) *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
▪ 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. All other flags will be held in the judging area. As described, a green flag will signal that the event is underway. 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.

P) *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.

- Q) *Fouls and Penalties* The Chief 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; and
- 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: 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 Chief Judge and the Judging Team. Penalty appeals may be filed in accordance with specified protest procedures.

- R) *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 Chief 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.

- S) *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.

- T) *Scoring* Vehicle rank in the endurance event is based on total distance travelled and average speed.

Average speed is computed after penalties have been assessed. The formula for average speed is:

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

The raw score for each vehicle is found by

$$\text{Raw Score} = \text{Distance Travelled} + 0.95 \left(\frac{V_{\text{Average}}}{V_{\text{Maximum Average}}} \right)$$

Points are awarded based on the raw score by

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

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

IX 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
Male Speed Event	12.5
Female Speed Event	12.5
Innovation Event	20
<u>Endurance Event</u>	<u>25</u>
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.

X 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 \$800 to team
 - Overall 2nd Place: Trophy and \$500 to team
 - Overall 3rd Place: Trophy and \$300 to team

Design Event	1 st + \$200, 2 nd and 3 rd place trophies
Men's Speed Event	1 st + \$200, 2 nd and 3 rd place trophies
Women's Speed Event	1 st + \$200, 2 nd and 3 rd place trophies
Innovation Event	1 st + \$200, 2 nd and 3 rd place trophies
Endurance Event	1 st + \$200, 2 nd and 3 rd place trophies

The winner of the Innovation event will receive the Novelty Award for Innovation.

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, male sprint or drag event, female 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
Team Spirit

Novelty Award for Innovation
Special Achievement

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.

XI 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 Chief Judge. Questions or recommended changes should be referred to the Chief Judge.
- B) *Chief Judge* The Chief Judge of the ASME Human Powered Vehicle Challenge serves a three year term and maintains the competition rules.

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

Questions about the rules may be sent to:

E-mail: hpv@asme.org

**XII 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.

For reference, the following lead times establish the deadlines:

Entry Date	8 weeks before Registration Date
Report Date	32 days before Registration Date
Update Date	Friday of competition during static vehicle judging
Registration Date	The initial day of competition (on-site)

Document	HPVC Form	Notes	Date Due
Entry Registration	Form 1		Entry Date
Certification of Eligibility	Form 2		Entry Date
Safety Certification	Form 3		Entry Date
Safety Ride Log	Form 3a		Registration Date
Safety Exemption Request	Form 4	<ul style="list-style-type: none"> ▪ Submit only if a exemption is requested ▪ Submit to Chief Judge 	Entry Date
Acknowledgment of Rules	Form 5		Entry date
Design Reports		ASME electronic submission	Report Date
Report Update		ASME electronic submission	Update Date
Vehicle Description	Form 6		Entry Date
Protests	Form 7	Submit to Chief Judge only if required	In accordance with II.J
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.

[http://www.asme.org/events/competitions/human-powered-vehicle-challenge-\(hpvc\)](http://www.asme.org/events/competitions/human-powered-vehicle-challenge-(hpvc))

**XIII Appendix 2
Design Event Judge's Score Sheet**