# Appendix D: Competition Level 2 Submission Template

**WATTS ON THE MOON CHALLENGE**

**PHASE 2 COMPETITION LEVEL 2**

**SUBMISSION TEMPLATE**

**INSTRUCTIONS:**

* This template must be saved as a PDF and uploaded using the HeroX application portal.
* The total page limit for the submission is 30 pages; Teams must adhere to this limit. A “page” is defined as 8 ½” X 11” size paper with 11-point font (Arial and 1-inch margins), single spaced. Any text included in tables, figures, or captions may be as small as 10-point font. The contents of any pages beyond page 30 of any submission will not be read or evaluated. This instruction section does not count toward the page limit and may be deleted prior to submission. Teams should maintain all numbered section headings in their submission.
* Each section includes a recommended length for the answer. These recommendations are intended to provide guidance on NASA’s expectations for the length and quality of the answer, but Teams are not required to adhere to these recommendations. Teams may allocate space to different sections as they see fit.
* You must complete the Team Information section. If the Team Affiliations/Organizations does not apply to your team, write “None.” If you skip any of these fields, your submission will be returned to be corrected.
* You must answer all questions in the Your Solution section. Any answer that is blank will be deemed incomplete. Teams should not submit answers such as “see previous answer” or “not applicable.” Such answers will be deemed incomplete. Any incomplete question will automatically receive zero points.
* Teams will be evaluated on each criterion, as described below in TABLE 5. For some criteria, Teams will receive points on a 0-10 point scale, as described in the judging rubric in [Appendix E](https://www.herox.com/WattsOnTheMoon/resource/922). For other criteria, Teams will be scored on a Pass/Fail basis. Teams will receive a score of “Pass” if they successfully demonstrate the performance described in the respective criterion. A total of 110 points is available, including a 10% bonus for Teams that demonstrate a full distance test (as described below in TABLE 5). Points will be weighted as described below in TABLE 5. To be eligible for a Competition Level 2 award, Teams must 1) receive a minimum score of 60 points (out of 110 points); and 2) receive no more than one “Fail” on the criteria scored Pass/Fail.

TABLE 5.

Scoring in Competition Level 2

|  |  |  |
| --- | --- | --- |
| **Criteria** | | **Weighting** |
| PERFORMANCE DEMONSTRATIONS AND RESULTS | | |
| Feasibility and progress toward performance tested in Competition Level 3 (including the quality and fidelity of sections 1.1 and 1.2 of the template and the performance results) | End-to-end efficiency of any power transmission system and roundtrip efficiency and energy capacity of any energy storage system | 20% |
| Mass of any power transmission system and mass of any energy storage system | 20% |
| Operation in temperatures and atmospheric pressures that will be tested in Competition Level 3 | 20% |
| Critical performance that cannot be tested in Competition Level 3 (including the quality and fidelity of section 1.2.4 of the template and the performance results) | Delivery of projected maximum power over a 3 km distance between the power source and load, where the demonstration is either a full-distance test or a combination of a partial-distance test and emulation or analysis of extrapolation to the full distance. | Scored Pass/Fail and teams that demonstrate a full distance test will receive bonus points in the amount of 10% of their total score |
| For energy storage systems, demonstration of 30 charge/discharge cycles 1) in Earth ambient conditions or a colder environment; 2) at a depth of discharge equal to the planned depth of discharge during operations in Competition Level 3 testing; and 3) with no more than 20% loss of energy capacity | Scored Pass/Fail |
| Additional performance metrics recommended by the team (if applicable) | Scored Pass/Fail |
| 1.3 Updated Schematics | | 5% |
| 1.4 Master Equipment List and Mass | | 10% |
| 1.5 Safety Analysis | | 10% |
| 3. Development Plan | | 5% |
| 4. Risk Assessment | | 5% |
| 5. Budget | | 5% |
| **TOTAL** | | **100% +**  **10% bonus**  **(as explained above)** |

**TEAM INFORMATION SECTION**

Team Name:

Team Lead:

Team Affiliations/Organizations (if applicable):

Geographic Location (City and State/Territory):

One Sentence Description: (*Provide a one-sentence description of your solution that can be used in promotional materials related to the challenge. Do not reference any confidential elements of your solution in this description*)

**YOUR SOLUTION SECTION**

1. Solution Design (Updated from Competition Level 1 submission)
   1. Updated Engineering Design
      1. Updated rationale for your design approach (*Recommended length: 1-2 pages*)
      2. Updated evidence and analysis predicting performance including efficiency, mass, and specific energy of key components of the system (*Recommended length: 2-4 pages*)
      3. Updated system-level and component-level design specifications for hardware and software (*Recommended length: 2 pages*)
      4. Updated description of how the system and components will address the Phase 2 Technical Requirements section of the rules (which outlines the performance that Teams will be expected to demonstrate in Competition Level 3 testing) (*Recommended length: 2 pages*)
   2. Key Analyses and/or Test Results
      1. Updated summary of concept of operations describing how your solution will address the conceptual load profile in FIGURE 1 (*Recommended length: 2-3 pages*)
      2. Updated summary of power efficiency analysis and estimate of total system efficiency (*Recommended length: 2-3 pages*)
      3. Updated summary of thermal analysis that addresses how your solution will tolerate/survive the environmental conditions in FIGURE 1 (*Recommended length: 2-3 pages*)
      4. Summary of testing and/or analysis that support critical performance that cannot be tested in Competition Level 3 (see PERFORMANCE RESULT TEMPLATE below) (*Recommended length: 1-2 pages*)
   3. Updated Schematics (*Recommended length: 1-2 pages*)

Provide schematics for key elements of your solution (such as power, control, and fluids) and assembly-level CAD models showing envelopes and key dimensions

* 1. Master Equipment List and Mass

Use the following EQUIPMENT TEMPLATE to provide an updated master equipment list, including mass and volume estimates and descriptions of internal and external interfaces. Estimated volume and interfaces will be used to help inform NASA’s testing plan in Competition Level 3 and will not be evaluated by judges. (*Recommended length: 1 page*)

EQUIPMENT TEMPLATE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Evaluated by Judges** | | ***For Informational Purposes Only*** | | |
| **Description of Equipment and Supplier** | **Estimated Total System Mass (kg)** | ***Estimated volume (cm3)*** | ***Internal interfaces*** | ***External interfaces*** |
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* 1. Updated Safety Analysis (*Recommended length: 2 pages*)
     1. Identify any potentially hazardous materials or other safety concerns related to your design and/or its operation that are relevant to testing your solution in a NASA facility in Competition Level 3.
     2. Provide an updated safety analysis addressing future transport and operation of your solution on the lunar surface, including related to any interactions with the NASA assets described in the challenge rules and potential interactions with humans.

1. Performance Results (*Recommended length: 1 page*)
   1. Using the PERFORMANCE CRITERIA TEMPLATE below, record the performance results achieved through testing or analysis prior to submission. You will then be expected to demonstrate those results during the observer visit. You should address the performance metrics listed below that are relevant to your solution; you may also add additional performance metrics specific to your solution.

NASA expects that your performance results at the site visit will be similar or better than the performance results provided in the submission. If your performance at the observer visit on any metric is less than performance result in the submission by more than a reasonable margin of error (10%), the judges will reduce your score for that metric.

If validation of a performance metric cannot be conducted during the observer visit (because, for example, a test cannot be completed in one day), you may submit a video demonstration of that performance for that metric in addition to this template.

PERFORMANCE CRITERIA TEMPLATE

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Metric** | **Performance**  **result at submission** | **Performance result recorded during the observer visit** | **Performance result demonstrated in a video** |
| End-to-end efficiency of any power transmission system |  |  |  |
| Mass of any power transmission system |  |  |  |
| Roundtrip efficiency and energy capacity of any energy storage system |  |  |  |
| Mass of any energy storage system |  |  |  |
| Operation in temperatures and atmospheric pressures that will be tested in Competition Level 3 |  |  |  |
| Delivery of projected maximum power over a 3 km distance between the power source and load, where the demonstration is either a full-distance test or a combination of a partial-distance test and emulation or analysis of extrapolation to the full distance. |  |  |  |
| For energy storage systems, demonstration of 30 charge/discharge cycles 1) in Earth ambient conditions or a colder environment; 2) at a depth of discharge equal to the planned depth of discharge during operations in Competition Level 3 testing; and 3) with no more than 20% loss of energy capacity |  |  |  |
| Additional performance recommended by the Team, if applicable |  |  |  |
| Additional performance recommended by the Team, if applicable |  |  |  |

1. Development Plan (*Recommended length: 1 page*)

Describe your plan for further developing your solution during Competition Level 3. Teams should address the technical steps necessary for hardware development; interface validation; personnel and other resources; and timeline in relation to Competition Level 3 submission deadline.

1. Risk Assessment (*Recommended length: 1 page*)

Describe the technical and other risks associated with developing your solution in Competition Level 3. For each risk, Teams should include an assessment (such as high, medium, low) and your proposed risk mitigation strategy.

1. Budget (*Recommended length: 1 page*)

Use the following BUDGET TEMPLATE to describe the budget necessary to execute the plan described in your answer to Section 3. In the “Expected funding sources” column, Teams should include whether you will already have funds in place to support work during Competition Level 3, and if not, how you will secure the necessary funds. You may assume the Competition Level 2 prize purse in your budget.

BUDGET TEMPLATE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Type of cost** | **Description** | **Necessary budget for Competition Level 2** | **Necessary budget for Competition Level 3** | **Expected funding source(s)** |
| Materials |  | N/A |  |  |
| Equipment |  | N/A |  |  |
| Lab/testing |  | N/A |  |  |
| Personnel |  | N/A |  |  |
| Other |  | N/A |  |  |
| Other |  | N/A |  |  |