**For the Phase 0/I Safety Data Package, provide the following information:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1a. Hardware Point-of-Contact: (Name/Company/Phone/Fax/email)** | | | | | | | | **1b. Hardware Name:** | | | | | | DRAGONFLY | | | |
| Yudai Etsunaga  Kyushu Institute of technology  +81-93-884-3229  etsunaga.yudai294@mail.kyutech.jp | | | | | | | | **Hardware Part Number:** | | | | | | DRAGONFLY-FM-01 | | | |
| **Hardware Acronym:** | | | | | | DRAGONFLY | | | |
| **Battery Name:** | | | | | | Ni-MH Battery | | | |
| **2a. Hardware / Battery Managing Group, Company, or Agency:** | | | | | | | | | | | | | | | | | |
| Kyushu Institute of Technology | | | | | | | | | | | | | | | | | |
| **2b. Hardware and Battery Environmental Requirements:** | | | | | | | | | | | | | | | | | |
| **Thermal Environment (max, min, operational and non-operational ranges):** | | | | | | | | | | | | | | | | | |
| +10 to +46 degC during launch (HTV, SpX, Cygnus envelope temperature),  -15 to +60 degC inside J-SSOD (When J-SSOD is outside the ISS)  [Note]: Battery specification: Storage: -20 to +50 degC  Since the battery thermal specification does not cover the thermal environment, we will confirm by thermal test. | | | | | | | | | | | | | | | | | |
| **Pressure Environment (EVA, IVA):** | | | | | | | | | | | | | | | | | |
| Both EVA and IVA environments. Maximum pressure during launch and inside the ISS is as follows. A pressure inside JEM Airlock at depressurization and outboard is 0 Pa.  Lunch vehicle and inside the ISS: 104.8 kPa. | | | | | | | | | | | | | | | | | |
| **Life (calendar/shelf, cycle/service):** | | | | | | | | | | | | | | | | | |
| Duration 3 years / Product warranty of storage is 5 years to keep more than 90% capacity from fully charged | | | | | | | | | | | | | | | | | |
| **3a. Battery and Hardware Description:** | | | | | | | | | | | | | | | | | |
| **Is the battery pack (including all components) Commercial-off-the-shelf (COTS)?** | | | | | | | | | | | | | | | | ☒Yes ☐ No | |
| **Function/Operating modes (continuous, pulse, intermittent, clock backup, memory, etc.):** | | | | | | | | | | | | | | | | | |
| No operation inside J-SSOD. Continuous operation after deployment. | | | | | | | | | | | | | | | | | |
| **Battery/Cell crew access on-orbit?** | | | | | | | ☐Yes ☒ No | | | | | | | | | | |
| **Short Description of Battery System: (Number of batteries to be flown; details if multiple batteries are required to power** Application, unique design information, etc.) | | | | | | | | | | | | | | | | | |
| Battery pack is in-house. EPS and FAB are COTS.  [Battery pack]  Part Name: DRAGONFLY-Battery  Type: NiMH Battery  Part Number: DRAGONFLY-Battery-01  Specification: 14.4 Wh  Manufacturer: Kyushu Institute of Technology  [FAB]  Part Name: DRAGONFLY-FAB  Part Number: BIRDSX-FAB-01  Manufacturer: Sagami Tsushin  [EPS]  Part Name: DRAGONFLY-EPS/OBC  Part Number: BIRDSX-EPS/OBC-01  Manufacturer: Sagami Tsushin | | | | | | | | | | | | | | | | | |
| **3b. Cell Description:** | | | | | | | | | | | | | | | | | |
| **Chemistry (If li-ion, what type: NMC, NCA, FePO4, etc.):** | | | | | | | | | | | | Ni-MH | | | | | |
| **Cell size:** | 14.35 mm dia. x 50.4 mm | | | | | | | | | | | | | | | | |
| **Manufacture and Model:** | | | | | Panasonic / BK-3MCC | | | | | | | | | | | | |
| **Nominal OCV:** | | 1.2 V | | | | | **Maximum Voltage:** | | | | | 1.6 V | | | **Minimum Voltage:** | | 1.0 V |
| **Rated Capacity:** | | | 2,000 mAh | | | | | | | | | | | | | | |
| **Maximum Rated OEM Discharge Current:** | | | | | | | | | Nonpublic information | | | | | | | | |
| **Maximum Recommended OEM Charge Current:** | | | | | | | | | | 2,000 mA | | | | | | | |
| **Minimum and Maximum OEM Discharge Temperatures:** | | | | | | | | | | | | 0 to +50 degC | | | | | |
| **Minimum and Maximum OEM Charge Temperatures:** | | | | | | | | | | | 0 to +40 degC | | | | | | |
| **Minimum and Maximum Storage Temperatures:** | | | | | | | | | | -20 to +40 degC | | | | | | | |
| **Date of Manufacture (Mo/Yr):** | | | | | | 01/2023 | | | | | | | | | | | |
| **3c. Battery Information: (9 V COTS batteries shall be considered as single units)** | | | | | | | | | | | | | | | | | |
| **Quantity of total cells:** | | | | 6 | | | | | | | | | | | | | |
| **Cell connectivity (#P#S, #S#P):** | | | | | | 3S2P | | | | | | | | | | | |
| **Operational Battery Environment Temperatures Range (Min/Max):** | | | | | | | | | | | | | 0 to +40 degC | | | | |
| **Nominal OCV:** | | 3.6 V | | | | | **Maximum Voltage:** | | | | | 4.8 V | | | **Minimum Voltage:** | | 3.0 V |
|  | | | | | | | | | | | | | | | | | |

**For the Phase II/III Safety Data Package, provide the following information:**

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| **Storage location (launch and on-orbit use locations):** |
| Installed inside CubeSat. BIRDS-X (2U CubeSat) will be launched to ISS by HTV-X, Cygnus or SpX with being installed inside J-SSOD (JEM Small Satellite Orbital Deployer) satellite install case or a dedicated launch case, which is soft stowed inside a bag. |
| **Packaging and hardware approved by flammability group (reference requirement):** |
| 1/10/2024 (MIUL) |
| **Is the battery charged on orbit?, Yes: ☐ No: ☒**  **If yes, describe charge rate, charger hardware, and protections to prevent overcharge** |
|  |
| **Is the battery being discharged on-orbit? Yes: ☐ No: ☒ If yes what is the discharge rate(s):** |
|  |
| **Circuit Description and Electrical Schematic (attach electronically or reference location in HR):** |
| All of the cells are covered by TEFLON panels and metal box same as BIRDS-1: EP-J-17-001 (Figure 1).  C:\Users\PC\OneDrive\BIRDS\EPS\Docs\Assembly procedures\Battery Assembly\battery_explode\new_ba3_explode.TIF  **Figure 1 Battery Box**  https://lh5.googleusercontent.com/S3Utn-mbgNZFwRRkZFSIcSftohmcWrr8Fkiqy82VAAO9p97a9cTzVLwP_snvyDoC6K2UOppBkgcdrVIGgYNL7rs5y_2EJNkQU57pHp5LJafeeaPcvmNAhW3dw7SWcwsnZFMylMu4  **Figure 2 Battery Connectivity**      **Figure 4-1 Inhibit schematic**  **Overcharge protection**  Sep SW1, Sep SW2 and DCDC converter are equipped in the solar cell side or the GND side of the battery as shown in Figure above. DCDC converter controls the input voltage from the solar cells to the battery pack to 4.2V.  **Over dis-charge protection**  *(Load Side)*  Sep SW2, Sep SW3 and SepSW4 are equipped in the Load side of the battery as shown in Figure 4-1.  *(Solar cell Side)*  Sep SW2, DCDC convertor and Isolation diodes are equipped in the Solar cell side of the battery as shown in Figure 4-1.  *(DepSW2 Side)*  Dep SW2 is equipped in the HOT side as shown in Figure 4-1. Double Insulation is set between the battery and the DepSW2. Proper charging before satellite delivery. This work is confirmed as VTL.  **External short protection**  *(Load Side)*  Sep SW2 and Sep SW3 are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switches.  *(Solar cell Side)*  Sep SW2 and DCDC convertor are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switch and DCDC convertor.  *(External power supply Side)*  Sep SW2 and DCDC convertor are equipped as shown in Figure 3. And double insulation is set between battery and Separation Switch and DCDC convertor.  *(Battery monitor Side)*  Sep SW2 is equipped in the GND side of the battery as shown in Figure 3. Double insulation is set between battery and Battery monitor connector. The battery monitor connector terminal will be covered with Kapton and double insulated at the time of satellite delivery. This work is confirmed as VTL.  *(DepSW2 Side)*  Sep SW2 is equipped as shown in Figure 3. Double insulation is set between the Drain of SepSW2 and the battery and the Gate of Sep SW2. |
| **Summary of circuit protections and include trip/reset points (i.e., fuses, diodes, MOSFETs, resistors, source isolation, etc.):** |
| Covered cables are used from the battery to GND or the first inhibit. The covered cables are further covered with Kapton tape to provide double insulation. In addition, GND and HOT terminals on a surface of a circuit board are covered with RTV, and the surface is covered with Kapton tape for double insulation. |
| **Battery testing complete and report uploaded to this HR? Yes: ☐ No: ☒**  **If yes, provide a short summary test results including anomalies or failures.** |
| **Summary of safety testing performed or planned:**    **Flowchart for screening test**  Following tests are performed for battery cells.   1. **Lot sampling Test** 2. Thermal Test   Thermal test of battery cell is performed for confirmation of temperature tolerance. Test condition is summarized as below.   * Temperature: more than +60 degree C * Test Duration: Over 2 hours   Before and after the thermal test, several function tests below are performed to see that there is no change in characteristics.   * Visual inspection (scratches, misaligned seals, electrolyte leakage, etc.) * Open Circuit Voltage (the change is less than 0.1%) * Mass (the change is less than 0.1%) * Capacity (the change is less than 5%) * Charge/Discharge Characteristic * Discharge Temperature         **Charge/Discharge Characteristics Test Configuration**   1. **Acceptance Test** 2. Random Vibration Test   Random vibration test for flight cells is performed for screening purpose.  Test condition is summarized as below.   * Vibration Level: Minimum Screening Level (MSL) * Tolerance: +/- 1.5dB for PSD * Direction: 2 axes (Radial direction and Axial direction) * Test Duration: Over 60 sec   **Table 4-1 Random Vibration Level for cells**   |  |  | | --- | --- | | **Freq. [Hz]** | **PSD [G2/Hz] (MSL)** | | 20 | 0.01 | | 80 | 0.04 | | 350 | 0.04 | | 2000 | 0.007 | | Overall | 6.06 Grms | | Duration | 1 min/axis |  1. Vacuum Test   Vacuum test of battery cell level is performed for screening. Test condition is summarized as below.   * Vacuum Level: less than 0.1 psia * Test Duration: Over 6 hours  1. Function Test   Before and after the environment tests (vibration test and vacuum test), several function tests below are performed to see that there is no change in characteristics.  Note that the Charge/Discharge Characteristics test measures the range between maximum voltage and minimum voltage.  Test Load: 1.9 [A] *\*In general, test is conducted with load between 0.2C and 1.0C*  Test Contents;   * Visual inspection (scratches, misaligned seals, electrolyte leakage, etc.) * Open Circuit Voltage (the change is less than 0.1%) * Mass (the change is less than 0.1%) * Capacity (the change is less than 5%) * Charge/Discharge Characteristic * Discharge Temperature  1. **Safety Function Test for System** 2. **Function Test for system**   After assembling the satellite, before and after the environmental test, the following functional tests are performed to confirm that there are no problems with the assembled battery.  Test content   * Open Circuit Voltage (Everyday for a 5 days) * - Take measurements once a day * - No testing using the battery will be performed during this test.  1. **Function Test for safety function**   DC/DC converter test against overcharging is conducted before/after the FM vibration test. Function of separation switches (Sep SW) will be confirmed after the FM vibration test. Functional tests are performed with the board assembled, but the solar panel is not assembled because the test is performed using the input line from the solar panel. To evaluate the electronic elements after the environmental test, the satellite must be disassembled, which is risky, so the evaluation is performed before the environmental test. On the other hand, mechanical switches are inspected after the environmental test because they may be broken in the environmental test. DC/DC converters and diodes are performed to vibration tests using a EM board to confirm environmental resistance.  **・SepSW1 test**  SepSW1 is on the battery charging line from solar panels. Place the satellite in front of a solar simulator with all Dep SW pressed.  When the satellite is exposed to the light of the solar simulator, the Inhibit (SepSW1) prevents the battery from charging when DepSW1 is pressed. On the other hand, after DepSW1 is released, the voltage will be applied to the battery line. Therefore, the soundness of SepSW1 can be confirmed by checking the source voltage to the battery from the solar panels.  **Figure 5 SepSW1 test configuration**  **・SepSW2,3,4 test**  Connect the debugger to the access port of the satellite so that serial data from the satellite can be output to an external PC.  When the satellite is in OFF-state and the debugger is connected between the satellite and the PC, there should be no output the serial data in the PC display. OFF-state of the satellite is when one of the Inhibits are pressed. On the other hand, the satellite is in ON-state when all inhibits are released, as such, the satellite should display information on the PC.  SepSW1 and SepSW3 can be operated by DepSW1, SepSW2 can be operated by DepSW2, and SepSW4 can be operated by DepSW3.  Check the serial data output when DepSW1, 2, and 3 are turned on respectively, and check the function of SepSW2, 3, and 4.  **・DCDC convertor test (for overcharge)**  The output of the solar cell is regulated by one DCDC converter to charge the battery. Connect an external power supply to the Back Plane Board and simulate the input voltage from the solar cell. Then, measure the DCDC output voltage from the connector that connects to the battery. The battery overcharged voltage is 4.8 V or higher. When the DC/DC input voltage is supplied by 5.2 V, we inspect the DC/DC output voltage should be below 4.2V by measuring the voltage at the battery slot.  **Figure6 DCDC convertor test configuration**  **・DCDC convertor test (for over-discharge and external short)**  Ensure that the DCDC converter prevents reverse current flow. Connect an external power supply to the FAB board instead of the battery. With DepSW2 turned on, check the voltage on the input and output sides of the DCDC converter. Verify that the voltage from the external power supply is applied to the output side and that the voltage is not applied to the input side.  **Figure7 DCDC convertor test configuration**  **・Diode test** (±Y and ±Z Solar cell side)  In order to check if current flows in the reverse direction of the diode, an electronic load is connected in place of the solar panels. The anode side of the diode under test is connected to the electronic load and a power supply is connected to the cathode side of the diode under test. When the electronic load is activated to draw current, the diode should prevent it from doing so.    **Figure 8 Diode test configuration**  **・Diode test** (±X Solar cell side)  In order to check if current flows in the reverse direction of the diode towards the solar cell, a resistor is connected at the solar panel board as it is connected to the anode side of the diode under test which then connected in series with a Digital Multimeter (set as ammeter) with negative probe connected to negative terminal of the power supply and the solar panel board (GND). The resistor serves as a load that will draw current from the solar panel board or from the battery. The power supply connect to the power line on the solar panel towards the battery. When the power supply is activated, it will provide current flow to the solar panel board. However, with the diode in between, there should be no current flowing as read by the connected digital multimeters.    **Figure 9 Diode test configuration** |
| **Has the pre-flight processing, flight acceptance plan, on-orbit processes, operational constraints, and the on-orbit and post-flight battery disposal plan for the hardware been conducted in accordance with JWI 8705.3?** |
| Yes: ☐ No: ☒ If yes, provide accompanying documentation. |
| No on-orbit processing of the battery is planned before CubeSat deployment from ISS.  CubeSat including the battery will not return to the ground but will be burned up at atmospheric reentry. |

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