

Battery Statistics & Operation:

1. 2 x Multistar -> 16000mAh, 18-22.2-25.2 V (Min-Nom-Max), 10C (160A Continuous, 320A 10 second burst), 6S1P, Off-the-shelf
 - a. Alternative: 1 x Zippy Flightmax -> 8000mAh, 12-14.4-16.8 V (Min-Nom-Max), 30C (240A Continuous, 300A 10 second burst), 4S1P, Off-the-shelf
2. Current/Voltage Draw: **Max Total = 12V, 12A**
 - a. 5A, Compact Rio (cRIO) and modules
 - b. 3A, solenoids (6 x 0.5A each)
 - c. 2A, SpaceX NAP (50W @ 12V)
 - d. 2A, Sensors and microprocessors
3. Fuses: Single 15A Fuse, In Line after power relay
4. Max Temperature: 50°C (Battery Operation Range:
 - a. 4 Battery temperature sensors (one at each corner of the battery)
5. Vacuum Information:
 - a. Pot internal is pressurized to 1atm which is primary mitigation for vacuum conditions
 - b. All main computer systems are in pod with only key sensors outside
 - c. Batteries are further protected via pressure pot which mitigates a sudden pod depressurization causing the batteries to explode
6. Power On/Off Measures:
 - a. Low Power Switch on High Power Relay
 - b. Software On/Off button (Kill's all power including cRIO's)
 - c. XT90 Connections
 - d. Removing Fuse
7. Expected Run times:
 - a. Test flights: ~30 min
 - b. Tube flight: ~45-60 min (includes depressurization)

Battery Unloading Procedure:

1. Clear area of any flammable materials
2. Place the batteries in their boxes in cleared area
3. Remove from batteries from box
4. Visually inspect battery for puffiness or other defects
 - a. If defects, look up exact procedures in manual or on manufacturers website
5. Check for nominal voltage using voltmeter across the terminals
6. Done

Battery Install Procedure:

1. Follow Battery Unloading Procedure
2. Visually verify that all wires are either terminated or kapton/electrical taped to avoid shorting
3. Visually verify that fuse is correctly installed and that current rating (15A) is in line

4. Visually verify that high power relay is bolted down and correctly wired such that batteries first pass through the 12V regulators before entering the 12V relay and low power mechanical switch (turns on high power relay)
5. Inspect batteries:
 - a. Check for welts or boils on the battery surface due to cell damage or problems
 - b. Check voltage using voltmeter to ensure proper charge (>22.2 for Multistar, >14.8 for Zippy). Done by probing across terminals, at 12V regulator output, and at the relay/mechanical switch input
6. Inspect internals of pressure pot to make sure no metal or conductive elements are present
7. Place one Multistar or Zippy into pot sitting power side up
8. Place AFO Fireball beside the battery offering support (use cardboard or foam to make snug)
9. Visually verify that nothing was missed in Step 6
10. Link XT90 connector between pressure pot pass through and battery (Does **not** power pod systems)
11. Ensure that no battery heat generation is occurring using the laser temperature probe
 - a. If heat generation occurs, quickly unplug the XT90 connectors and verify the absence of shorts
 - b. With no heat generation, focus on XT90 connection and ensure that fit is snug
12. Ensure temperature sensors are correctly mounted to battery and pressure sensor is sufficiently isolated from metal walls
13. Hook Arduino to sensor out/power in and verify safe internal conditions and operation (<30° C and ~14.7 psi)
14. Keep Arduino linked and carefully close pressure pot lid
15. Visually ensure from Arduino serial out that nothing has shorted (XT90's) and that temperature/pressure isn't rising
16. Link XT90 connector between pot pass through and power relay (Does **not** power on pod systems)
17. Ensure that no battery, regulator or relay heat generation is occurring using the laser temperature probe and Arduino
 - a. If heat generation quickly unplug the XT90 connectors
18. Continue to probe regulator, sensors, and cRIO using laser temperature probe for roughly 120 seconds
19. Verify correct regulator and power relay operation using voltmeter to probe regulator and relay voltages (should be ~12V)
20. Done

Power On Procedure:

1. Follow Battery Install Procedure to correctly install the batteries
 - a. If batteries were installed previously use temperature probe and voltmeter to probe regulators and relay for irregularities (may also want to probe battery terminals to ensure nominal voltage)

2. Visually verify no shorts or unexpected connections down line from the high power relay and that low power switch is correctly wired
3. Supply jump-start high to MOSFET gate to unblock mechanical switch
4. Flip low power mechanical switch to on position (turns on high power relay power **all** systems, sensors and actuators to default position)
 - a. Expected current draw: ~8A
5. Remove external power from MOSFET gate (gate is now be held open by cRIO and can be powered down via software)
6. Ensure that no battery heat generation is occurring using the laser temperature probe
 - a. If heat generation quickly flip switch off and unplug the XT90 connectors
7. Probe exit of power relay and various key circuit points using voltmeter to ensure proper power
 - a. If unanticipated results, flip switch to off and re-inspect circuits for unintended connections before starting over
8. Done

Battery Off Procedure:

1. Turn off power from GUI (using input button)
2. Flip mechanical switch to Off position
3. Use pass-through to check voltage by probing the high and low power pins
4. Done

Battery Removal Procedure:

1. Follow Battery Off Procedure to ensure power is off
2. Probe voltages using voltmeter and check temperatures using temperature laser probe
3. Unplug XT90 from pass through to power relay
4. Vent pressure pot using manual vent pull plug
 - a. While venting use Arduino setup from Install Procedure (Step 13) to monitor pressure pot temperature and pressure
5. Assuming healthy state (<30°C and ~1atm) received from Arduino, carefully remove pressure pot lid
 - a. If Arduino shows hot: Use gloves to remove top
 - b. If Arduino shows pressure buildup or dropout: Use manual vent on top to pressurize to external pressure (~1 atm)
6. Visually inspect battery before continuing to ensure no defects (puffiness) has occurred due to malfunction
7. Remove pressure pot to battery XT90 connector
8. Remove AFO Fireball, any battery padding and the temperature/pressure sensors
9. Remove Battery
10. Done