



Shark of the Sky Hybrid Rocket 2019 IREC

Launch Operations Procedures

Compiled on 2019-06-14

Background and Reference

Contents

This document contains two nominal procedures:

- **N1**, *Final Setup and Pre-Launch Checks*, comprises the final checks and tests performed on the Remote Launch Control System (RLCS) prior to rocket launch, as well as avionics systems arming.
- **N2**, *Fill and Launch Operations*, comprises steps for oxidizer fill and rocket launch.

Additionally, this document contains five abort procedures:

- **A1**, *Abort Procedure - Leak At Supply Plumbing*, is used if a plumbing leak is detected when the supply cylinder is initially opened.
- **A2**, *Abort Procedure - Low Supply Pressure*, is used if the oxidizer pressure is below the acceptable limit for launch.
- **A3**, *Abort Procedure - High Supply Pressure*, is used if the oxidizer pressure is above the acceptable limit for launch.
- **A4**, *Abort Procedure - Leak At Fill Plumbing*, is used if a plumbing leak is detected during manual fill leak checks.
- **A5**, *Abort Procedure - Remote Disconnect or Ignition Failure*, is used if the remote disconnect or ignition systems fail, necessitating a full vent of the oxidizer tank.
- **A γ** , *Abort Procedure - Voice Contact Loss*, is used if the operators at the launch site lose the ability to communicate with the operators at launch control.

Personnel Required

The launch operations team consists of four personnel:

- 1 ☐ The **Operations Director [OPS]** is stationed at Launch Control. **OPS** directs operations procedures and communicates with the other launch personnel.
- 2 ☐ The **Control System Operator [CONTROL]** is stationed at Launch Control and is responsible for operation of RLCS, including remote fill, disconnect, and ignition.
- 3 ☐ The **Primary Fill Operator [PRIMARY]** is initially stationed at the Launch Tower and carries out all tasks occurring at the Launch Tower. **PRIMARY** engages the remote disconnect system, arms the vehicle recovery deployment system, connects the ignition wires to the rocket, and operates all manual valves during the manual portion of fill.
- 4 ☐ The **Secondary Fill Operator [SECONDARY]** is the backup for **PRIMARY**, and communicates with **OPS**. If **PRIMARY** becomes incapacitated, **SECONDARY** is responsible for removing them from danger.

Sign-Off

To be completed by all test personnel after reading and familiarization with procedures

- | | | | |
|---|---|-------|-------|
| 1 | <input type="checkbox"/> Operations Director [OPS] | _____ | _____ |
| 2 | <input type="checkbox"/> Control System Operator [CONTROL] | _____ | _____ |
| 3 | <input type="checkbox"/> Primary Fill Operator [PRIMARY] | _____ | _____ |
| 4 | <input type="checkbox"/> Secondary Fill Operator [SECONDARY] | _____ | _____ |

[N1] Final Setup and Pre-Launch Checks

Prior to Start

- 1 ☐ Ensure that the following procedures are complete:
 - 2 ☐ Rocket Assembly procedure
 - 3 ☐ RLCS Setup procedure
 - 4 ☐ Launch Tower Setup procedure
- 5 ☐ Ensure that all personnel as defined above are available and have completed the sign-off.
- 6 ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
 - 7 ☐ OPS
 - 8 ☐ CONTROL
 - 9 ☐ PRIMARY
 - 10 ☐ SECONDARY
- 11 ☐ Ensure that OPS is in possession of the system control key.
- 12 ☐ Ensure that the client-side RLCS box is powered off.
- 13 ☐ Ensure that the locations of Launch Control, Launch Tower, and the Minimum Safe Distance are clearly defined.

Launch Control	Launch Tower	Minimum Safe Distance

Nominal Procedure

- 1 ☐ PRIMARY: Confirm that the following valves are initially closed:
 - 2 ☐ Cylinder Valve
 - 3 ☐ Remote Fill Valve
 - 4 ☐ Parallel Fill Valve
 - 5 ☐ Series Fill Valve
 - 6 ☐ Line Vent Valve
 - 7 ☐ Parallel Vent Valve
- 8 ☐ PRIMARY: Confirm that the ignition connectors are disconnected from the rocket.
- 9 ☐ SECONDARY: Confirm that the voltage across the ignition connectors is 0 V.
- 10 ☐ OPS: Give the system control key to CONTROL.
- 11 ☐ CONTROL: Confirm that all actuator controls are in the off/closed state:

- 12 ☐ Remote Fill Valve
- 13 ☐ Line Vent Valve
- 14 ☐ Remote Disconnect
- 15 ☐ Primary Ignition
- 16 ☐ Secondary Ignition
- 17 ☐ Injector Valve
- 18 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 19 ☐ **CONTROL** and **SECONDARY**: Confirm that all actuators actuate as intended:
 - 20 ☐ Remote Fill Valve
 - 21 ☐ Line Vent Valve
 - 22 ☐ Remote Disconnect
 - 23 ☐ Injector Valve
- 24 ☐ **CONTROL** and **SECONDARY**: Confirm that the ignition voltage is 12 V when the ignition button is fired:
 - 25 ☐ Primary Ignition
 - 26 ☐ Secondary Ignition
- 27 ☐ **CONTROL**: Confirm that all DAQ readings are displaying appropriately.
- 28 ☐ **OPS**: Record the resting DAQ values:

[M] Dry Mass (lbs)	[P1] Supply Pressure (psi)	[P2] Fill Line Pressure (psi)	[P3] Oxidizer Tank Pressure (psi)

- 29 ☐ **CONTROL**: Remove the system control key and give it to **OPS**.
- 30 ☐ **PRIMARY**: Arm recovery avionics using the magnetic switches
- 31 ☐ **PRIMARY**: Arm remote disconnect by connecting the springs and fill adapter.
- 32 ☐ **PRIMARY**: Connect the ignition connectors to the rocket.

[N2] Fill and Launch Operations

Prior to Start

- 1 ☐ Ensure that the following procedure is complete:
- 2 ☐ **N1**, *Final Setup and Pre-Launch Checks*
- 3 ☐ Ensure that all personnel are available and have completed the sign-off.
- 4 ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
- 5 ☐ **OPS**
- 6 ☐ **CONTROL**
- 7 ☐ **PRIMARY**
- 8 ☐ **SECONDARY**
- 9 ☐ Ensure that **PRIMARY** and **SECONDARY** are wearing face shields and have no exposed skin.
- 10 ☐ Ensure that **PRIMARY** is wearing thermal gloves.
- 11 ☐ Ensure that **OPS** is in possession of the system control key.

Nominal Procedure

- 1 ☐ **SECONDARY**: Confirm that no personnel other than **PRIMARY** and **SECONDARY** are within the Minimum Safe Distance.
- 2 ☐ **OPS**: Confirm that the actuator key switch is disabled and that only **OPS** is in possession of the system control key.
- 3 ☐ **OPS**: Confirm that the Range Safety Officer and Launch Control Officer have given clearance to proceed with fill procedures.
- 4 ☐ **CONTROL**: Confirm that the RLCS client-side box is on and displaying DAQ information.
- 5 ☐ **PRIMARY**: Confirm that the following valves are initially closed:
- 6 ☐ Cylinder Valve
- 7 ☐ Remote Fill Valve
- 8 ☐ Parallel Fill Valve
- 9 ☐ Series Fill Valve
- 10 ☐ Line Vent Valve
- 11 ☐ Parallel Vent Valve
- 12 ☐ **OPS**: Confirm that the Pressure Relief Valve is initially closed.
- 13 ☐ **OPS**: Confirm that the Injector Valve is initially closed.
- 14 ☐ **PRIMARY**: Slowly open the Cylinder Valve through $\frac{3}{4}$ of a turn.
 - If leaks are observed:
- 15 ☐ **OPS**: Proceed to procedure A1.
- 16 ☐ **PRIMARY**: Communicate the supply line pressure as visible on the Pressure Gauge.

- If the supply line pressure is below 800 psi:

☐ **OPS**: Proceed to procedure **A2**.

- If the supply line pressure exceeds 1000 psi:

☐ **OPS**: Proceed to procedure **A3**.

☐ **CONTROL**: Confirm that the supply line pressure as read by **PRIMARY** agrees with the supply line pressure [P1] measured by the DAQ system.

☐ **OPS**: Record the resting rocket dry mass and supply pressure:

[M] Dry Mass (lbs)	[P1] Supply Pressure (psi)

☐ **PRIMARY**: Open the Series Fill Valve.

☐ **PRIMARY** and **SECONDARY**: Retreat 100 ft from the fill system.

☐ **OPS**: Give the system control key to **CONTROL**.

☐ **CONTROL**: Confirm the following valves are closed:

☐ Remote Fill Valve

☐ Remote Vent Valve

☐ **CONTROL**: Engage the key switch and enable actuators.

☐ **CONTROL**: Open the Remote Fill Valve.

☐ **CONTROL**: Confirm the following pressures are increasing:

☐ [P2] Fill line pressure

☐ [P3] Oxidizer tank pressure

☐ **CONTROL**: Close the Remote Fill Valve.

☐ **CONTROL**: Confirm the following pressures are stable:

☐ [P2] Fill line pressure

☐ [P3] Oxidizer tank pressure

- If the pressures are decreasing:

☐ **OPS**: Proceed to procedure **A4**.

☐ **CONTROL**: Open the Remote Vent Valve.

☐ **CONTROL**: Confirm the following pressures are atmospheric:

☐ [P2] Fill line pressure

☐ [P3] Oxidizer tank pressure

☐ **CONTROL**: Disengage the key switch and disable actuators

☐ **PRIMARY** and **SECONDARY**: Retreat to the Minimum Safe Distance.

- 43 ☐ **SECONDARY**: Confirm that **PRIMARY** and **SECONDARY** are at the Minimum Safe Distance.
- 44 ☐ **PAUSE POINT**
- 45 ☐ **CONTROL**: Confirm that all actuator controls are in the off state:
- 46 ☐ Remote Fill Valve
- 47 ☐ Line Vent Valve
- 48 ☐ Remote Disconnect
- 49 ☐ Primary Ignition
- 50 ☐ Secondary Ignition
- 51 ☐ Injector Valve
- 52 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 53 ☐ **CONTROL**: Open the Remote Fill Valve.
- 54 ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure.
- 55 ☐ **OPS**: Proceed only when the following is true:
- 56 ☐ Rocket mass [M] plateaus
- 57 ☐ Oxidizer tank pressure [P3] is within the acceptable limits
- 58 ☐ **CONTROL**: Close the Remote Fill Valve.
- 59 ☐ **CONTROL**: Open the Remote Vent Valve.
- 60 ☐ **CONTROL**: Confirm that the fill line pressure [P2] is atmospheric.
- 61 ☐ **CONTROL**: Actuate Remote Disconnect.
- 62
 - If Remote Disconnect fails to actuate:
 - ☐ **OPS**: Proceed to procedure **A5**.
- 63 ☐ **PAUSE POINT**
- 64 ☐ **OPS**: Perform pre-launch checks:
- 65 ☐ Request clearance for launch from the Launch Control Officer.
- 66 ☐ Confirm that all members are aware of launch.
- 67 ☐ **PRIMARY**: Perform engine startup procedure:
- 68 ☐ Arm the Primary Ignition switch.
- 69 ☐ Hold down the Fire button until the Primary current reading drops to 0 A.
- 70
 - In the event of a failed ignition (current drop not observed within 1 minute):
 - ☐ **PRIMARY**: Disarm the Primary Ignition switch.
 - ☐ **PRIMARY**: Arm the Secondary Ignition switch.
 - ☐ **OPS**: Revisit ignition procedure.
 - In the event of a second failed ignition (current drop not observed within 1 minute):
 - ☐ **PRIMARY**: Disarm the Secondary Ignition switch.
 - ☐ **OPS**: Proceed to procedure **A5**.
- 71 ☐ **PRIMARY**: Start the engine by opening the Injector Valve.
- 72 ☐ **ALL**: Observe the rocket during takeoff, ascent, and recovery:
- 73
- 74
- 75
- 76

- 77 ☐ First vehicle motion
- 78 ☐ Launch rail departure
- 79 ☐ Engine burnout
- 80 ☐ Payload deployment
- 81 ☐ Drogue parachute deployment
- 82 ☐ Main parachute deployment
- 83 ☐ Approximate recovery area/direction
- 84 ☐ **CONTROL**: Disarm RLCS:
 - 85 ☐ Disable actuator control by removing the system control key.
 - 86 ☐ Give the system control key to **OPS**.
- 87 ☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.
- 88 ☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.
- 89 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
- 90 ☐ **PRIMARY**: Close the Cylinder Valve.
- 91 ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 92 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 93 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 94 ☐ **OPS**: Give the master key to **CONTROL**
- 95 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 96 ☐ **CONTROL**: Open the Remote Fill Valve.
- 97 ☐ **CONTROL**: Confirm that the supply line pressure [P1] is atmospheric.
- 98 ☐ **PRIMARY**: Disconnect the supply line from the supply cylinder.
- 99 ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 100 ☐ **OPS**: Proceed with teardown and disassembly.

Abort Procedures

[A1] Abort Procedure - Leak At Supply Plumbing

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [P1] Supply pressure
 - 6 ☐ [P2] Fill line pressure
- 7 ☐ **PRIMARY**: Disarm the system:
 - 8 ☐ Disconnect the ignition leads from the rocket.
 - 9 ☐ Detach the torsion springs from the disconnect mechanism.
 - 10 ☐ Disarm the recovery electronics system using the magnetic switches.
 - 11 ☐ Disarm the payload using the transponder.
 - 12 ☐ Disconnect the fill line from the supply cylinder.
 - 13 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 14 ☐ **OPS**: Revisit plumbing setup.

[A2] Abort Procedure - Low Supply Pressure

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [P1] Supply pressure
 - 6 ☐ [P2] Fill line pressure
- 7 ☐ **PRIMARY**: Allow the supply cylinder to warm up.
- 8 ☐ **OPS**: Revisit **N1**.

[A3] Abort Procedure - High Supply Pressure

- 1 ☐ **PRIMARY**: Close the Cylinder Valve.
- 2 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ [P1] Supply pressure
 - 6 ☐ [P2] Fill line pressure
- 7 ☐ **PRIMARY**: Disarm the system:

- 8 ☐ Disconnect the ignition leads from the rocket.
- 9 ☐ Detatch the torsion springs from the disconnect mechanism.
- 10 ☐ Disarm the recovery electronics system using the magnetic switches.
- 11 ☐ Disarm the payload using the transponder.
- 12 ☐ Disconnect the fill line from the supply cylinder.
- 13 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 14 ☐ **OPS**: Revisit cylinder cooling methods.

[A4] Abort Procedure - Leak At Fill Plumbing

- 1 ☐ **CONTROL**: Close the Remote Fill Valve.
- 2 ☐ **CONTROL**: Open the Remote Vent Valve.
- 3 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 4 ☐ P2: Fill line pressure
 - 5 ☐ P3: Rocket Tank pressure
- 6 ☐ **PRIMARY** and **SECONDARY**: Return to plumbing setup
- 7 ☐ **PRIMARY**: Close the Cylinder Valve.
- 8 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 9 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 10 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 11 ☐ [P1] Supply pressure
 - 12 ☐ [P2] Fill line pressure
- 13 ☐ **PRIMARY**: Disarm the system:
 - 14 ☐ Disconnect the ignition leads from the rocket.
 - 15 ☐ Detatch the torsion springs from the disconnect mechanism.
 - 16 ☐ Disarm the recovery electronics system using the magnetic switches.
 - 17 ☐ Disarm the payload using the transponder.
 - 18 ☐ Disconnect the fill line from the supply cylinder.
 - 19 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 20 ☐ **OPS**: Revisit plumbing setup.

[A5] Abort Procedure - Remote Disconnect or Ignition Failure

- 1 ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure as the oxidizer tank vents.
- 2 ☐ **OPS**: Proceed only when the following is true:
 - 3 ☐ Rocket mass is equal to the pre-launch recorded mass
 - 4 ☐ Oxidizer tank pressure [P3] is atmospheric
 - 5 ☐ The Launch Control Officer has given clearance to approach the Launch Tower.
- 6 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.

- 7 ☐ **PRIMARY**: Close the Cylinder Valve.
- 8 ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 9 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 10 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 11 ☐ **OPS**: Give the system control key to **CONTROL**
- 12 ☐ **CONTROL**: Engage the system control switch and enable actuators.
- 13 ☐ **CONTROL**: Open the Remote Fill Valve.
- 14 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 15 ☐ [P1] Supply pressure
 - 16 ☐ [P2] Fill line pressure
- 17 ☐ **PRIMARY**: Disarm the system:
 - 18 ☐ Disconnect the ignition leads from the rocket.
 - 19 ☐ Detach the torsion springs from the disconnect mechanism.
 - 20 ☐ Disarm the recovery electronics system using the magnetic switches.
 - 21 ☐ Disarm the payload using the transponder.
 - 22 ☐ Disconnect the fill line from the supply cylinder.
 - 23 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 24 ☐ **OPS**: Proceed with teardown and disassembly.

[Aγ] Abort Procedure - Voice Contact Loss - For Launch Control Operators

- 1 ☐ **CONTROL**: Remove the system control key from the client side box.
- 2 ☐ **OPS**: Attempt to regain communication with the operators at the pad:
 - 3 ☐ Send "**OPS** to **SECONDARY**, **OPS** to **SECONDARY**, **SECONDARY** please come in".
 - If contact is restored:
 - 4 ☐ Return to normal operations.
 - 5 ☐ Check batteries in radio.
 - 6 ☐ Check that radio is set to the proper channel.
 - 7 ☐ Check that radio volume is high enough.
 - 8 ☐ Wait 30 seconds, then send message again.
 - If contact is restored:
 - 9 ☐ Return to normal operations.
- 10 ☐ **OPS**: Wait 30 seconds.
- 11 ☐ **OPS**: Send "**OPS** to **SECONDARY**, **OPS** to **SECONDARY**, going to full abort. I say again, going to full abort."
- 12 ☐ **OPS**: Inform the ESRA official that launch operations will be aborted.
- 13 ☐ **OPS**: Wait for operators to return from pad.
- 14 ☐ **OPS**: Proceed with teardown and disassembly.

[Aγ] Abort Procedure - Voice Contact Loss - For Launch Pad Operators

- 1 ☐ **SECONDARY**: Attempt to regain communication with the operators at launch control:
- 2 ☐ Send "**SECONDARY** to **OPS**, **SECONDARY** to **OPS**, **OPS** please acknowledge".
 - 3 • If contact is restored:
 - 4 ☐ Return to normal operations.
 - 4 ☐ Check batteries in radio.
 - 5 ☐ Check that radio is set to the proper channel.
 - 6 ☐ Check that radio volume is high enough.
 - 7 ☐ Wait 30 seconds, then send message again.
 - 8 • If contact is restored:
 - 9 ☐ Return to normal operations.
- 9 ☐ **SECONDARY** and **PRIMARY**: Approach the rocket, listening for hisses coming from fill system
- 10 ☐ **PRIMARY**: Close the Cylinder Valve.
- 11 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 12 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 13 ☐ **SECONDARY** and **PRIMARY**: Return to launch control.