



Unexploded Ordnance Hybrid Rocket 2018 IREC

Launch Operations Procedures

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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.

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 ☐ CONTROL: Power on the client-side RLCS box.
- 10 ☐ CONTROL and SECONDARY: Confirm that the following actuators fail to move:
 - 11 ☐ Remote Fill Valve

- 12 ☐ Line Vent Valve
- 13 ☐ Remote Disconnect
- 14 ☐ Injector Valve
- 15 ☐ **SECONDARY**: Confirm that the voltage across the ignition connectors is 0 V.
- 16 ☐ **OPS**: Give the system control key to **CONTROL**.
- 17 ☐ **CONTROL**: Confirm that all actuator controls are in the off state:
 - 18 ☐ Remote Fill Valve
 - 19 ☐ Line Vent Valve
 - 20 ☐ Remote Disconnect
 - 21 ☐ Tank Vent Valve
 - 22 ☐ Primary Ignition
 - 23 ☐ Secondary Ignition
 - 24 ☐ Injector Valve
- 25 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 26 ☐ **CONTROL** and **SECONDARY**: Confirm that all actuators actuate as intended:
 - 27 ☐ Remote Fill Valve
 - 28 ☐ Line Vent Valve
 - 29 ☐ Remote Disconnect
 - 30 ☐ Tank Vent Valve
 - 31 ☐ Injector Valve
- 32 ☐ **CONTROL** and **SECONDARY**: Confirm that the ignition voltage is 12 V when the ignition button is fired:
 - 33 ☐ Primary Ignition
 - 34 ☐ Secondary Ignition
- 35 ☐ **CONTROL**: Confirm that all DAQ readings are displaying appropriately.
- 36 ☐ **CONTROL**: Remove the system control key and give it to **OPS**.
- 37 ☐ **PRIMARY**: Arm the payload using the transponder.
- 38 ☐ **PRIMARY**: Arm recovery avionics using the magnetic switches
- 39 ☐ **PRIMARY**: Arm remote disconnect by connecting the springs, fill adapter, and strap.
- 40 ☐ **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 Tank Vent Valve is initially open.
- 13 ☐ **OPS**: Confirm that the Pressure Relief Valve is initially closed.
- 14 ☐ **OPS**: Confirm that the Injector Valve is initially closed.
- 15 ☐ **PRIMARY**: Slowly open the Cylinder Valve through $\frac{3}{4}$ of a turn.
 - If leaks are observed:
- 16 ☐ **OPS**: Proceed to procedure A1.

- 17 ☐ **PRIMARY**: Communicate the supply line pressure as visible on the Pressure Gauge.
- If the supply line pressure is below 800 psi:
- 18 ☐ **OPS**: Proceed to procedure **A2**.
- If the supply line pressure exceeds 1000 psi:
- 19 ☐ **OPS**: Proceed to procedure **A3**.
- 20 ☐ **CONTROL**: Confirm that the supply line pressure as read by **PRIMARY** agrees with the supply line pressure [P1] measured by the DAQ system.
- 21 ☐ **OPS**: Record the resting rocket dry mass and supply pressure:

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

- 22 ☐ **PRIMARY**: Open the Series Fill Valve.
- 23 ☐ **PRIMARY** and **SECONDARY**: Retreat 100 ft from the fill system.
- 24 ☐ **OPS**: Give the system control key to **CONTROL**.
- 25 ☐ **CONTROL**: Confirm the following valves are closed:
- ☐ Remote Fill Valve
 - ☐ Remote Vent Valve
 - ☐ Tank Vent Valve
- 29 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 30 ☐ **CONTROL**: Open the Remote Fill Valve.
- 31 ☐ **CONTROL**: Confirm the following pressures are increasing:
- ☐ [P2] Fill line pressure
 - ☐ [P3] Oxidizer tank pressure
- 34 ☐ **CONTROL**: Close the Remote Fill Valve.
- 35 ☐ **CONTROL**: Confirm the following pressures are stable:
- ☐ [P2] Fill line pressure
 - ☐ [P3] Oxidizer tank pressure
- If the pressures are decreasing:
- 38 ☐ **OPS**: Proceed to procedure **A4**.
- 39 ☐ **CONTROL**: Open the Remote Vent Valve.
- 40 ☐ **CONTROL**: Open the Tank Vent Valve.
- 41 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
- 42 ☐ [P2] Fill line pressure

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

- 77 ☐ **PRIMARY**: Arm the Secondary Ignition switch.
- 78 ☐ **OPS**: Revisit ignition procedure.
 - In the event of a second failed ignition (current drop not observed within 1 minute):
- 79 ☐ **PRIMARY**: Disarm the Secondary Ignition switch.
- 80 ☐ **OPS**: Proceed to procedure **A5**.
- 81 ☐ **PRIMARY**: Start the engine by opening the Injector Valve.
- 82 ☐ **ALL**: Observe the rocket during takeoff, ascent, and recovery:
 - 83 ☐ First vehicle motion
 - 84 ☐ Launch rail departure
 - 85 ☐ Engine burnout
 - 86 ☐ Payload deployment
 - 87 ☐ Drogue parachute deployment
 - 88 ☐ Main parachute deployment
 - 89 ☐ Approximate recovery area/direction
- 90 ☐ **CONTROL**: Disarm RLCS:
 - 91 ☐ Disable actuator control by removing the system control key.
 - 92 ☐ Give the system control key to **OPS**.
- 93 ☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.
- 94 ☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.
- 95 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
- 96 ☐ **PRIMARY**: Close the Cylinder Valve.
- 97 ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 98 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 99 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 100 ☐ **OPS**: Give the master key to **CONTROL**
- 101 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 102 ☐ **CONTROL**: Open the Remote Fill Valve.
- 103 ☐ **CONTROL**: Confirm that the supply line pressure [P1] is atmospheric.
- 104 ☐ **PRIMARY**: Disconnect the supply line from the supply cylinder.
- 105 ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 106 ☐ **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 Tank Vent Valve.
- 3 ☐ **CONTROL**: Open the Remote Vent Valve.
- 4 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 5 ☐ P2: Fill line pressure
 - 6 ☐ P3: Rocket Tank pressure
- 7 ☐ **PRIMARY** and **SECONDARY**: Return to plumbing setup
- 8 ☐ **PRIMARY**: Close the Cylinder Valve.
- 9 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 10 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 11 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
 - 12 ☐ [P1] Supply pressure
 - 13 ☐ [P2] Fill line pressure
- 14 ☐ **PRIMARY**: Disarm the system:
 - 15 ☐ Disconnect the ignition leads from the rocket.
 - 16 ☐ Detatch the torsion springs from the disconnect mechanism.
 - 17 ☐ Disarm the recovery electronics system using the magnetic switches.
 - 18 ☐ Disarm the payload using the transponder.
 - 19 ☐ Disconnect the fill line from the supply cylinder.
 - 20 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 21 ☐ **OPS**: Revisit plumbing setup.

[A5] Abort Procedure - Remote Disconnect or Ignition Failure

- 1 ☐ **CONTROL**: Open the Tank Vent Valve.
- 2 ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure as the oxidizer tank vents.
- 3 ☐ **OPS**: Proceed only when the following is true:
 - 4 ☐ Rocket mass is equal to the pre-launch recorded mass
 - 5 ☐ Oxidizer tank pressure [P3] is atmospheric

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