



# Unexploded Ordnance Hybrid Rocket 2018 IREC

Launch Operations Procedures

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# Background and Reference

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## Contents

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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 $\gamma$** , *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

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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

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

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

## [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 turned 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: Turn on the client side RLCS box.
- 10 ☐ CONTROL and SECONDARY: Confirm that all 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

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### Prior to Start

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- 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

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- 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 1050 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 measured by the DAQ system.
- 21 ☐ **OPS**: Record the resting rocket dry mass and supply pressure:

Dry Mass (lbs)	Supply Pressure (psi)

- 22 ☐ **PRIMARY**: Open the Series Fill Valve.
- 23 ☐ **PRIMARY** and **SECONDARY**: Retreat 100ft away from rocket.
- 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**: Use control key to arm client side box.
- 30 ☐ **CONTROL**: Open the Remote Fill Valve.
- 31 ☐ **CONTROL**: Confirm that the pressures in the fill lines and in the oxidizer tank are increasing.
- 32 ☐ **CONTROL**: Close the Remote Fill Valve.
- 33 ☐ **CONTROL**: Confirm that the pressures in the fill lines and in the oxidizer tank are stable.
- If the pressures are decreasing (probable leak detected):
- 34 ☐ **OPS**: Proceed to procedure **A4**.
- 35 ☐ **CONTROL**: Open the Remote Vent Valve.
- 36 ☐ **CONTROL**: Open the Tank Vent Valve.
- 37 ☐ **CONTROL**: Confirm the following pressures are atmospheric:
- ☐ P2: Fill line pressure
  - ☐ P3: Rocket Tank pressure
- 40 ☐ **CONTROL**: Disengage the key switch and disable actuators
- 41 ☐ **PRIMARY** and **SECONDARY**: Retreat to the Minimum Safe Distance.
- 42 ☐ **SECONDARY**: Confirm that **PRIMARY** and **SECONDARY** are at the Minimum Safe Distance.

- 43 ☐ **PAUSE POINT**
- 44 ☐ **CONTROL**: Confirm that all actuator controls are in the off state:
- 45 ☐ Remote Fill Valve
- 46 ☐ Line Vent Valve
- 47 ☐ Remote Disconnect
- 48 ☐ Tank Vent Valve
- 49 ☐ Primary Ignition
- 50 ☐ Secondary Ignition
- 51 ☐ Injector Valve
- 52 ☐ **CONTROL**: Engage the key switch and enable actuators.
- 53 ☐ **CONTROL**: Open the Tank Vent Valve.
- 54 ☐ **CONTROL**: Open the Remote Fill Valve.
- 55 ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure.
- 56 ☐ **OPS**: Proceed only when the following is true:
- 57 ☐ Rocket mass plateaus
- 58 ☐ Oxidizer tank pressure is within the acceptable limits
- 59 ☐ **CONTROL**: Close the Tank Vent Valve.
- 60 ☐ **CONTROL**: Close the Remote Fill Valve.
- 61 ☐ **CONTROL**: Open the Remote Vent Valve.
- 62 ☐ **CONTROL**: Confirm that the fill line pressure is atmospheric.
- 63 ☐ **CONTROL**: Actuate Remote Disconnect.
- 64
  - If Remote Disconnect fails to actuate:
    - ☐ **OPS**: Proceed to procedure **A5**.
- 65 ☐ **PAUSE POINT**
- 66 ☐ **OPS**: Perform pre-launch checks:
- 67 ☐ Request clearance for launch from the Launch Control Officer.
- 68 ☐ Confirm that all members are aware of launch.
- 69 ☐ **PRIMARY**: Perform engine startup procedure:
- 70 ☐ Arm the Primary Ignition switch.
- 71 ☐ Hold down the Fire button until the Primary current reading drops to 0 A.
- 72
  - 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.
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  - 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**.
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- 77        ☐ **PRIMARY**: Start the engine by opening the Injector Valve.
- 78    ☐ **ALL**: Observe the rocket during takeoff, ascent, and recovery:
- 79        ☐ First vehicle motion
- 80        ☐ Launch rail departure
- 81        ☐ Engine burnout
- 82        ☐ Payload deployment
- 83        ☐ Drogue parachute deployment
- 84        ☐ Main parachute deployment
- 85        ☐ Approximate recovery area/direction
- 86    ☐ **CONTROL**: Disarm RLCS:
- 87        ☐ Disable actuator control by removing the system control key.
- 88        ☐ Give the system control key to **OPS**.
- 89    ☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.
- 90    ☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.
- 91    ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
- 92    ☐ **PRIMARY**: Close the Cylinder Valve.
- 93    ☐ **PRIMARY**: Open the Parallel Vent Valve.
- 94    ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 95    ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
- 96    ☐ **OPS**: Give the master key to **CONTROL**
- 97    ☐ **CONTROL**: Engage the key switch and enable actuators.
- 98    ☐ **CONTROL**: Open the Remote Fill Valve.
- 99    ☐ **CONTROL**: Confirm that the supply line pressure is atmospheric.
- 100   ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 101   ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 102   ☐ **OPS**: Proceed with teardown and disassembly.



## Abort Procedures

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### [A1] Abort Procedure - Leak At Supply Plumbing

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- 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 that the fill and supply pressures are atmospheric.
- 5 ☐ **PRIMARY**: Disarm the system:
  - 6 ☐ Disconnect the ignition leads from the rocket.
  - 7 ☐ Detach the torsion springs from the disconnect mechanism.
  - 8 ☐ Disarm the recovery electronics system using the magnetic switches.
  - 9 ☐ Disarm the payload using the transponder.
  - 10 ☐ Disconnect the fill line from the supply cylinder.
  - 11 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 12 ☐ **OPS**: Revisit plumbing setup.

### [A2] Abort Procedure - Low Supply Pressure

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- 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 that the fill and supply pressures are atmospheric.
- 5 ☐ **PRIMARY**: Allow the supply cylinder to warm up.
- 6 ☐ **OPS**: Revisit **N1**.

### [A3] Abort Procedure - High Supply Pressure

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- 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 that the fill and supply pressures are atmospheric.
- 5 ☐ **PRIMARY**: Disarm the system:
  - 6 ☐ Disconnect the ignition leads from the rocket.
  - 7 ☐ Detach the torsion springs from the disconnect mechanism.
  - 8 ☐ Disarm the recovery electronics system using the magnetic switches.
  - 9 ☐ Disarm the payload using the transponder.
  - 10 ☐ Disconnect the fill line from the supply cylinder.
  - 11 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 12 ☐ **OPS**: Revisit cylinder cooling methods.

#### [A4] Abort Procedure - Leak At Fill Plumbing

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- 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 that the fill and supply pressures are atmospheric.
- 12 ☐ **PRIMARY**: Disarm the system:
  - 13 ☐ Disconnect the ignition leads from the rocket.
  - 14 ☐ Detatch the torsion springs from the disconnect mechanism.
  - 15 ☐ Disarm the recovery electronics system using the magnetic switches.
  - 16 ☐ Disarm the payload using the transponder.
  - 17 ☐ Disconnect the fill line from the supply cylinder.
  - 18 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 19 ☐ **OPS**: Revisit plumbing setup.

#### [A5] Abort Procedure - Remote Disconnect or Ignition Failure

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- 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 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 that the supply line pressure is atmospheric.
- 16    ☐ **PRIMARY**: Disarm the system:
  - 17        ☐ Disconnect the ignition leads from the rocket.
  - 18        ☐ Detatch the torsion springs from the disconnect mechanism.
  - 19        ☐ Disarm the recovery electronics system using the magnetic switches.
  - 20        ☐ Disarm the payload using the transponder.
  - 21        ☐ Disconnect the fill line from the supply cylinder.
  - 22        ☐ Replace the cap on the nitrous oxide supply cylinder.
- 23    ☐ **OPS**: Proceed with teardown and disassembly.

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

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- 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. Say again, going to full abort.
- 12    ☐ **OPS**: Inform the ESRA official that we have 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

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- 1    ☐ **SECONDARY**: Attempt to regain communication with the operators at launch control:
- 2        ☐ Send "**SECONDARY** to **OPS**, **SECONDARY** to **OPS**, **OPS** please come in".
  - 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.