



# 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.

## 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

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### Prior to Start

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- 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.

### Nominal Procedure

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- 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    ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- If leaks are observed:
- 22        ☐ **OPS**: Proceed to procedure **A4**.
- 23    ☐ **CONTROL**: Confirm that the pressures in the fill lines and in the oxidizer tank are increasing.
- 24    ☐ **PRIMARY**: Close the Parallel Fill Valve.
- 25    ☐ **PRIMARY**: Open the Series Fill Valve.
- 26    ☐ **PRIMARY** and **SECONDARY**: Retreat to the Minimum Safe Distance.
- 27    ☐ **SECONDARY**: Confirm that **PRIMARY** and **SECONDARY** are at the Minimum Safe Distance.
- 28    ☐ **PAUSE POINT**
- 29    ☐ **OPS**: Give the system control key to **CONTROL**.
- 30    ☐ **CONTROL**: Confirm that all actuator controls are in the off state:
- 31        ☐ Remote Fill Valve
  - 32        ☐ Line Vent Valve
  - 33        ☐ Remote Disconnect
  - 34        ☐ Tank Vent Valve
  - 35        ☐ Primary Ignition
  - 36        ☐ Secondary Ignition
  - 37        ☐ Injector Valve
- 38    ☐ **CONTROL**: Engage the key switch and enable actuators.
- 39    ☐ **CONTROL**: Open the Remote Fill Valve.
- 40    ☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure.
- 41    ☐ **OPS**: Proceed only when the following is true:
- 42        ☐ Rocket mass plateaus
  - 43        ☐ Oxidizer tank pressure is within the acceptable limits
- 44    ☐ **CONTROL**: Close the Tank Vent Valve.
- 45    ☐ **CONTROL**: Close the Remote Fill Valve.
- 46    ☐ **CONTROL**: Open the Remote Vent Valve.
- 47    ☐ **CONTROL**: Confirm that the fill line pressure is atmospheric.
- 48    ☐ **CONTROL**: Actuate Remote Disconnect.

- If Remote Disconnect fails to actuate:

☐ **OPS**: Proceed to procedure **A5**.

☐ **PAUSE POINT**

☐ **OPS**: Perform pre-launch checks:

☐ Request clearance for launch from the Launch Control Officer.

☐ Confirm that all members are aware of launch.

☐ **PRIMARY**: Perform engine startup procedure:

☐ Arm the Primary Ignition switch.

☐ 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):

☐ **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**.

☐ **PRIMARY**: Start the engine by opening the Injector Valve.

☐ **ALL**: Observe the rocket during takeoff, ascent, and recovery:

☐ First vehicle motion

☐ Launch rail departure

☐ Engine burnout

☐ Payload deployment

☐ Drogue parachute deployment

☐ Main parachute deployment

☐ Approximate recovery area/direction

☐ **CONTROL**: Disarm RLCS:

☐ Disable actuator control by removing the system control key.

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

☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.

☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.

☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.

☐ **PRIMARY**: Close the Cylinder Valve.

☐ **PRIMARY**: Open the Parallel Vent Valve.

☐ **PRIMARY**: Slowly open the Parallel Fill Valve.

☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.

☐ **OPS**: Give the master key to **CONTROL**

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

- 83    ☐ **CONTROL**: Open the Remote Fill Valve.
- 84    ☐ **CONTROL**: Confirm that the supply line pressure is atmospheric.
- 85    ☐ **PRIMARY**: Disconnect the fill line from the supply cylinder.
- 86    ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
- 87    ☐ **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 Fill Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Vent 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 Fill Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Vent 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 Fill Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Vent 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 ☐ **PRIMARY**: Close the Parallel Fill Valve.
- 2 ☐ **PRIMARY**: Close the Cylinder Valve.
- 3 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- 4 ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- 5 ☐ **CONTROL**: Confirm that the fill and supply pressures are atmospheric.
- 6 ☐ **PRIMARY**: Disarm the system:
  - 7 ☐ Disconnect the ignition leads from the rocket.
  - 8 ☐ Detatch the torsion springs from the disconnect mechanism.
  - 9 ☐ Disarm the recovery electronics system using the magnetic switches.
  - 10 ☐ Disarm the payload using the transponder.
  - 11 ☐ Disconnect the fill line from the supply cylinder.
  - 12 ☐ Replace the cap on the nitrous oxide supply cylinder.
- 13 ☐ **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.