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.
- **Aγ**, *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 ☐ **Operations Director [OPS]** _____ _____

2 ☐ **Control System Operator [CONTROL]** _____ _____

3 ☐ **Primary Fill Operator [PRIMARY]** _____ _____

4 ☐ **Secondary Fill Operator [SECONDARY]** _____ _____

[N1] Final Setup and Pre-Launch Checks

Prior to Start

- ☐ Ensure that the following procedures are complete:
  - ☐ Rocket Assembly procedure
  - ☐ RLCS Setup procedure
  - ☐ Launch Tower Setup procedure
- ☐ Ensure that all personnel as defined above are available and have completed the sign-off.
- ☐ Ensure that the following personnel have walkie-talkies and communication is functional:
  - ☐ **OPS**
  - ☐ **CONTROL**
  - ☐ **PRIMARY**
  - ☐ **SECONDARY**
- ☐ Ensure that **OPS** is in possession of the system control key.
- ☐ Ensure that the client-side RLCS box is powered off.
- ☐ 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

- ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - ☐ Cylinder Valve
  - ☐ Remote Fill Valve
  - ☐ Parallel Fill Valve
  - ☐ Series Fill Valve
  - ☐ Line Vent Valve
  - ☐ Parallel Vent Valve
- ☐ **PRIMARY**: Confirm that the ignition connectors are disconnected from the rocket.
- ☐ **CONTROL**: Power on the client-side RLCS box.
- ☐ **CONTROL** and **SECONDARY**: Confirm that the following actuators fail to move:
  - ☐ Remote Fill Valve

- ☐ Line Vent Valve
- ☐ Remote Disconnect
- ☐ Injector Valve

☐ **SECONDARY**: Confirm that the voltage across the ignition connectors is 0 V.

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

☐ **CONTROL**: Confirm that all actuator controls are in the off state:

- ☐ Remote Fill Valve
- ☐ Line Vent Valve
- ☐ Remote Disconnect
- ☐ Tank Vent Valve
- ☐ Primary Ignition
- ☐ Secondary Ignition
- ☐ Injector Valve

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

☐ **CONTROL** and **SECONDARY**: Confirm that all actuators actuate as intended:

- ☐ Remote Fill Valve
- ☐ Line Vent Valve
- ☐ Remote Disconnect
- ☐ Tank Vent Valve
- ☐ Injector Valve

☐ **CONTROL** and **SECONDARY**: Confirm that the ignition voltage is 12 V when the ignition button is fired:

- ☐ Primary Ignition
- ☐ Secondary Ignition

☐ **CONTROL**: Confirm that all DAQ readings are displaying appropriately.

☐ **OPS**: Record the resting DAQ values:

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

☐ **CONTROL**: Remove the system control key and give it to **OPS**.

☐ **PRIMARY**: Arm the payload using the transponder.

☐ **PRIMARY**: Arm recovery avionics using the magnetic switches

☐ **PRIMARY**: Arm remote disconnect by connecting the springs, fill adapter, and strap.

☐ **PRIMARY**: Connect the ignition connectors to the rocket.

[N2] Fill and Launch Operations

Prior to Start

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

Nominal Procedure

- ☐ **SECONDARY**: Confirm that no personnel other than **PRIMARY** and **SECONDARY** are within the Minimum Safe Distance.
- ☐ **OPS**: Confirm that the actuator key switch is disabled and that only **OPS** is in possession of the system control key.
- ☐ **OPS**: Confirm that the Range Safety Officer and Launch Control Officer have given clearance to proceed with fill procedures.
- ☐ **CONTROL**: Confirm that the RLCS client-side box is on and displaying DAQ information.
- ☐ **PRIMARY**: Confirm that the following valves are initially closed:
  - ☐ Cylinder Valve
  - ☐ Remote Fill Valve
  - ☐ Parallel Fill Valve
  - ☐ Series Fill Valve
  - ☐ Line Vent Valve
  - ☐ Parallel Vent Valve
- ☐ **OPS**: Confirm that the Tank Vent Valve is initially open.
- ☐ **OPS**: Confirm that the Pressure Relief Valve is initially closed.
- ☐ **OPS**: Confirm that the Injector Valve is initially closed.
- ☐ **PRIMARY**: Slowly open the Cylinder Valve through $\frac{3}{4}$ of a turn.
  - If leaks are observed:
    - ☐ **OPS**: Proceed to procedure A1.

☐ **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
- ☐ Tank Vent Valve

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

☐ **CONTROL**: Open and close the Tank Vent Valve, ensuring that the limit switch reading updates accordingly.

☐ **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**: Open the Tank 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.

☐ **SECONDARY**: Confirm that **PRIMARY** and **SECONDARY** are at the Minimum Safe Distance.

☐ **PAUSE POINT**

☐ **CONTROL**: Confirm that all actuator controls are in the off state:

- ☐ Remote Fill Valve
- ☐ Line Vent Valve
- ☐ Remote Disconnect
- ☐ Tank Vent Valve
- ☐ Primary Ignition
- ☐ Secondary Ignition
- ☐ Injector Valve

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

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

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

☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure.

☐ **OPS**: Proceed only when the following is true:

- ☐ Rocket mass [M] plateaus
- ☐ Oxidizer tank pressure [P3] is within the acceptable limits

☐ **CONTROL**: Close the Tank Vent Valve.

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

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

☐ **CONTROL**: Confirm that the fill line pressure [P2] is atmospheric.

☐ **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):

77 ☐ **PRIMARY**: Disarm the Primary Ignition switch.
78 ☐ **PRIMARY**: Arm the Secondary Ignition switch.
79 ☐ **OPS**: Revisit ignition procedure.

- In the event of a second failed ignition (current drop not observed within 1 minute):

80 ☐ **PRIMARY**: Disarm the Secondary Ignition switch.
81 ☐ **OPS**: Proceed to procedure **A5**.
82 ☐ **PRIMARY**: Start the engine by opening the Injector Valve.
83 ☐ **ALL**: Observe the rocket during takeoff, ascent, and recovery:
84 ☐ First vehicle motion
85 ☐ Launch rail departure
86 ☐ Engine burnout
87 ☐ Payload deployment
88 ☐ Drogue parachute deployment
89 ☐ Main parachute deployment
90 ☐ Approximate recovery area/direction
91 ☐ **CONTROL**: Disarm RLCS:
92 ☐ Disable actuator control by removing the system control key.
93 ☐ Give the system control key to **OPS**.
94 ☐ **OPS**: Confirm that RLCS is disarmed and **OPS** is in possession of the system control key.
95 ☐ **OPS**: Proceed only when clearance is received from the Launch Control Officer to approach the Launch Tower.
96 ☐ **PRIMARY** and **SECONDARY**: Approach the Launch Tower.
97 ☐ **PRIMARY**: Close the Cylinder Valve.
98 ☐ **PRIMARY**: Open the Parallel Vent Valve.
99 ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
100 ☐ **PRIMARY** and **SECONDARY**: Retreat 20 ft from the fill system.
101 ☐ **OPS**: Give the master key to **CONTROL**
102 ☐ **CONTROL**: Engage the key switch and enable actuators.
103 ☐ **CONTROL**: Open the Remote Fill Valve.
104 ☐ **CONTROL**: Confirm that the supply line pressure [P1] is atmospheric.
105 ☐ **PRIMARY**: Disconnect the supply line from the supply cylinder.
106 ☐ **PRIMARY**: Replace the cap on the nitrous oxide supply cylinder.
107 ☐ **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. ☐ 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 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:

- ☐ Disconnect the ignition leads from the rocket.
- ☐ Detatch the torsion springs from the disconnect mechanism.
- ☐ Disarm the recovery electronics system using the magnetic switches.
- ☐ Disarm the payload using the transponder.
- ☐ Disconnect the fill line from the supply cylinder.
- ☐ Replace the cap on the nitrous oxide supply cylinder.

☐ **OPS**: Revisit cylinder cooling methods.

[A4] Abort Procedure - Leak At Fill Plumbing

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

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

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

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

- ☐ P2: Fill line pressure
- ☐ P3: Rocket Tank pressure

☐ **PRIMARY** and **SECONDARY**: Return to plumbing setup

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

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

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

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

- ☐ [P1] Supply pressure
- ☐ [P2] Fill line pressure

☐ **PRIMARY**: Disarm the system:

- ☐ Disconnect the ignition leads from the rocket.
- ☐ Detatch the torsion springs from the disconnect mechanism.
- ☐ Disarm the recovery electronics system using the magnetic switches.
- ☐ Disarm the payload using the transponder.
- ☐ Disconnect the fill line from the supply cylinder.
- ☐ Replace the cap on the nitrous oxide supply cylinder.

☐ **OPS**: Revisit plumbing setup.

[A5] Abort Procedure - Remote Disconnect or Ignition Failure

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

☐ **CONTROL**: Monitor the RLCS display for rocket mass and oxidizer tank pressure as the oxidizer tank vents.

☐ **OPS**: Proceed only when the following is true:

- ☐ Rocket mass is equal to the pre-launch recorded mass
- ☐ Oxidizer tank pressure [P3] is atmospheric

- ☐ The Launch Control Officer has given clearance 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 system control key to **CONTROL**

☐ **CONTROL**: Engage the system control switch and enable actuators.

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

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

- ☐ [P1] Supply pressure
- ☐ [P2] Fill line pressure

☐ **PRIMARY**: Disarm the system:

- ☐ Disconnect the ignition leads from the rocket.
- ☐ Detatch the torsion springs from the disconnect mechanism.
- ☐ Disarm the recovery electronics system using the magnetic switches.
- ☐ Disarm the payload using the transponder.
- ☐ Disconnect the fill line from the supply cylinder.
- ☐ Replace the cap on the nitrous oxide supply cylinder.

☐ **OPS**: Proceed with teardown and disassembly.

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

☐ **CONTROL**: Remove the system control key from the client side box.

☐ **OPS**: Attempt to regain communication with the operators at the pad:

- ☐ Send "**OPS** to **SECONDARY**, **OPS** to **SECONDARY**, **SECONDARY** please come in".
  - If contact is restored:
    - ☐ Return to normal operations.
- ☐ Check batteries in radio.
- ☐ Check that radio is set to the proper channel.
- ☐ Check that radio volume is high enough.
- ☐ Wait 30 seconds, then send message again.
  - If contact is restored:
    - ☐ Return to normal operations.

☐ **OPS**: Wait 30 seconds.

☐ **OPS**: Send "**OPS** to **SECONDARY**, **OPS** to **SECONDARY**, going to full abort. Say again, going to full abort."

☐ **OPS**: Inform the ESRA official that launch operations will be aborted.

☐ **OPS**: Wait for operators to return from pad.

☐ **OPS**: Proceed with teardown and disassembly.

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

- ☐ **SECONDARY**: Attempt to regain communication with the operators at launch control:
  - ☐ Send "**SECONDARY** to **OPS**, **SECONDARY** to **OPS**, **OPS** please come in".
    - If contact is restored:
      - ☐ Return to normal operations.
  - ☐ Check batteries in radio.
  - ☐ Check that radio is set to the proper channel.
  - ☐ Check that radio volume is high enough.
  - ☐ Wait 30 seconds, then send message again.
    - If contact is restored:
      - ☐ Return to normal operations.
- ☐ **SECONDARY** and **PRIMARY**: Approach the rocket, listening for hisses coming from fill system
- ☐ **PRIMARY**: Close the cylinder valve.
- ☐ **PRIMARY**: Slowly open the Parallel Vent Valve.
- ☐ **PRIMARY**: Slowly open the Parallel Fill Valve.
- ☐ **SECONDARY** and **PRIMARY**: Return to launch control.