



UAH Propulsion Research Center
 OPERATING PROCEDURE FOR:
Deployment Controller Demonstration

SOP #: PRC-SOP-USLI-020
 Revision: A
 Version: 0
 Test Location: PRC Test Cell

Test Date: _____

Test Team

NAME	ROLE

This Procedure Contains the following Hazards

<input type="checkbox"/>	Human Subjects	<input type="checkbox"/>	Animal Subjects
<input type="checkbox"/>	Highly Toxic Chemicals	<input type="checkbox"/>	Toxins or toxin products
<input type="checkbox"/>	Pressurized gases	<input checked="" type="checkbox"/>	Explosives/Propellants
<input type="checkbox"/>	Microbial agents/products	<input type="checkbox"/>	Cell or tissue culture
<input type="checkbox"/>	Lasers	<input type="checkbox"/>	Selected Agents
<input type="checkbox"/>	Radioisotopes or x-ray generating equipment	<input type="checkbox"/>	Carcinogenic/mutagenic/teratogenic chemicals
<input type="checkbox"/>	Human blood, body fluid, tissue	<input type="checkbox"/>	Recombinant DNA/RNA molecules



REVISION BLOCK

Operating Procedures may be modified either through a Revision or a Version increment. Revision Increments require a new Signoff Sheet and full approval. Version increments are for minor corrections or additions to Red Team members. Version increments only require new Red Team signature and a single approval from PRC Staff.

VER#	REASON FOR REVISION	VERSION APPROVAL	DEV. HOURS
0	<i>New SOP for 2018-2019 ULSI</i>	<i>See Signature Page</i>	<i>13</i>

ACTIVE WAIVERS

The following waivers have been reviewed by the procedure approval team and are accepted based on assessment of additional mitigations put into effect for conducting the test

#	DESCRIPTION	MITIGATION	EXPIRES	RESPONSIBILITY
1	<i>N/A</i>			



PROCEDURE REVISION APPROVAL:

I have personally reviewed each of the operational steps of the SOP and have no questions that the operation can be performed safely and efficiently. I approve all red team personnel assigned in this document and verify that they have proper training to act in the prescribed test roles outlined in this procedure.

Hope Cash: _____ **Date:** _____

Author

Colton Connor: _____ **Date:** _____

Vehicle Lead

Connor Gisburne: _____ **Date:** _____

Payload Safety Lead

Marcus Shelton: _____ **Date:** _____

Chief Engineer

Zachary Ruta: _____ **Date:** _____

Program Manager

Jason Winningham: _____ **Date:** _____

Mentor

Dr. David Lineberry: _____ **Date:** _____

Course Instructor



Dr. Robert Frederick: _____

Date: _____

PRC Director

Reviewed By:

UAH OEHS Director: _____

Date: _____



AUTHORIZED RED TEAM MEMBERS

Individuals identified below are authorized to participate in test operations as *Red Team Members* through the SOP approval signatures. By signing the document below, the individuals acknowledge that they have reviewed the procedure and understand the general and specific safety requirements, personnel limits, and work descriptions necessary to accomplish their part of the operation.

Additional Red Team Members may be added to this document without a procedure revision pending approval of the PRC Director or Laboratory Supervisor or Facility Engineer prior to participating in the experiment. Additional members require signatures of both the individual to be added and the approver.

Authorized test individuals agree to abide by and follow the procedure outlined in this document for conducting the described experiment. At a minimum, Red Team Members must maintain active First Aid/CPR/AED certification.

Red Team Members	Affiliation	First Aid/ CPR-AED Cert Date	PRC Safety Quiz	Signature	Approval Initials
David Lineberry	PRC Staff	9/20/2017	Feb 2018		
Jason Winningham	Mentor	6/8/2018	Feb 2018		
Connor Gisburne	MAE 491 Student	10/18/2018	Sept 2018		
Bao Ha	Graduate Mentor	10/13/2017	Jan 2019		
Daniel Corey	MAE 491 Student	8/14/2018	Sept 2018		
Colton Connor	MAE 491 Student	10/5/2018	Sept 2018		
Tanner Schmitt`	MAE 491 Student	10/5/2018	Sept 2018		



SECTION I. DECLARATIONS.

1. Objective

This SOP establishes procedures and defines safety precautions that will be used to verify that the deployment controller is capable of igniting E-Matches prior to black power charge demonstrations. Success will be defined as if the following sequence is executed by both primary and backup channels:

- Buzzer changes from 5 Hz beeping to continuous tone
- 5 – 10 second delay in which the green LED on the capacitor bank lights up
- Solenoid latch retracts
- 0.5 second delay
- Expected E-Match fires
- 3 second delay
- Solenoid latch extends
- LED blink rate moves from 5 Hz to 1 Hz and buzzer tone ceases

2. Test Location

The PRC Test Cell at the Johnson Research Center on the UAH campus will be the location of testing. This provides a secured and controlled access area. For testing, personnel must be at least 10ft away from the test article.

3. Roles and Responsibilities

This procedure requires a minimum of 2 test operators one of which must be PRC staff or mentor. Operator roles will be assigned on the day of testing. Each operator will be assigned a role and that role will be identified on the procedure cover sheet (pg 1). Test operator roles are identified below:

Safety Monitor: *is responsible for monitoring safety.*

Test Conductor: *is responsible for directly conducting the test and assembly.*

4. Observer Policy

Observers will be allowed under this test procedure at the discretion of the test team. The occupation limitations of the room apply to observers as well as test participants. Any observer must be briefed on the experiment hazards, emergency procedures prior to test operations, and listed on the title page of the procedure.

5. Safety Policy

All PRC test operations require a minimum of two operators with First Aid, CPR, and AED training. Test operations are carried out according to the PRC Facility Usage Policy outlined in PRC-SOP-001-R01. A copy of the facility usage policy may be found on the PRC website <http://UAH.edu/prc>. All personnel involved with this operation have been empowered to stop any portion of this operation at any time if they feel it is not proceeding in a safe manner. The PRC Director, PRC Research Engineer/Laboratory Supervisor, PRC Facility Engineer, and other



required personnel will be notified and a decision on whether to continue the operation will be made at that time. No safety interlock will be modified, bypassed, or defeated unless the test team has concurred and are aware of the inherent risks associated with the change. Otherwise, the offender will be permanently expelled from the PRC and all of its facilities.

6. Personal Protective Equipment (PPE)

Test personnel must wear safety glasses at all times during test operations. Closed toed shoes are also required for testing. Nearby Fire Extinguisher must be on hand or locations identified prior to testing.

7. Procedure Deviations

At any point during the execution of this SOP any team member may call for a stand down of test operations to discuss any concern related to safety. Additionally, during the execution of the SOP any deviation to the procedures outlined in this document must be noted on the procedure and it must be identified on the cover page that deviations were conducted. Revisions to the procedure may be required prior to the next test operation. Prior to each test, verify that the procedures do not require modification due to specific test plan requirements. In the event that redlines are required during execution, ensure that the redlines present no safety, efficiency, or environmental concerns.

8. Materials Needed

Assembled Payload Deployment Controller	Mini-USB cable
Small Phillip’s screwdriver	Laptop computer with any serial terminal program
Small flathead screwdriver	2 clamps or vices
2 CR123 batteries	2 centrifuge cups
2 E-Matches	Gorilla tape
Assembled Interface Hardware	A set of paired XBee radios with antenna
Safety glasses	XBee Explorer board



SECTION II. TEST PROCEDURES.

▲ ALL PERSONNEL WILL WEAR SAFETY GLASSES THROUGHOUT THESE PROCEDURES

SYSTEM SETUP

- 1 Inform all guests of emergency exits and other pertinent safety information.
- 2 Identify nearest AED location to team and guests.
- 3 Place all jewelry and electronic devices, including cell phones, tablets, and radios in an approved location.
- 4 **Make sure all personnel are wearing the proper PPE, e.g., safety glasses etc.**
- 5 If testing at the JRC,
 - Place warning barricades around test cell
 - Turn warning light to YELLOW during the set-up procedure and throughout the experiment.
- 6 Setup camera to record test (optional).
- 7 **Remove any unnecessary equipment and all flammable material from test area**
- 8 Install door latch solenoid onto upper airframe bulkhead using the screws, washers, and nuts
- 9 Secure upper airframe bulkhead using vise or clamps
- 10 Plug the door latch solenoid into header J6 on the deployment circuit board
- 11 Plug the capacitor bank into the unlabeled header with the yellow electrical tape on the deployment circuit board
- 12 Plug the power switch into header SW2 on the deployment circuit board
- 13 Plug the latch detect switch into header SW1 on the deployment circuit board
- 14 Install 2x CR123 batteries into deployment circuit board
- 15 Verify/set SW3 on the deployment circuit board to the ON position
- 16 Secure deployment circuit board using vise or clamps
- 17 Plug 1 XBee radio (with antenna) into deployment circuit board
- 18 Plug the other XBee radio (with antenna) into the XBee explorer board
- 19 Connect XBee explorer board to computer over USB cable

SOFTWARE VERIFICATION/SETUP

- 20 Open serial terminal on laptop
- PRC-SOP-USLI-020-RA-V0 Deployment Controller Demonstration



- 21 Connect serial terminal to appropriate COM port
- 22 Set serial terminal baud rate to 9600 baud
- 23 Verify/set deployment controller to on using power switch
- 24 Verify red LED on deployment controller blinking at approximately 1 Hz
- 25 Send text "UAH_CRW_DEPLOYMENT_CHECK_VERSION", terminated by a newline (\n) character. Do not include quotes
- 26 Verify board responds with "Deployment Control System V0.1.0 - NOT FOR FLIGHT"
- 27 Set deployment controller to off using power switch

E-MATCH INSTALLATION

- 28 Verify all personnel wearing safety glasses
- 29 Verify/set deployment controller to off using power switch
- 30 Verify no LEDs lit on deployment controller circuit board
 - The LED light provides an indication that the circuit is live. Red LED indicates the circuit is powered.*
- 31 Place each E-match in centrifuge cup
- 32 Install 1 E-match in the J1 screw terminal
- 33 Install 1 E-match in the J3 screw terminal
- 34 Secure E-matches away from any flammable material; e.g. to the side of a vise. Space them at least 2" apart
- 35 Verify all personnel except the person operating the switch are a minimum of 10 ft away from the matches
- 36 Set the deployment controller to on using the power switch
- 37 All personnel move a minimum of 10 ft away from the matches

CONTROLLER ARM

- 38 From the serial terminal, send text "UAH_CRW_arm_payload_deployment", terminated by a newline (\n) character. Do not include quotes
- 39 Verify rapid (~5 Hz) beeps coming from controller
- 40 Verify rapid red LED flashing at same rate as controller beeping



PRIMARY E-MATCH TEST

- 41 All personnel move at least 10ft away from system
- 42 Confirm high speed rate camera is ready
- 43 From the serial terminal, send text "UAH_CRW_deploy_payload_primary", terminated by a newline (\n) character. Do not include quotes
- 44 Observe automatic sequence. Sequence concludes when payload stops beeping and changes to a 1 Hz red LED blink rate
 - If payload has not stopped beeping
 - From the serial terminal, send text "UAH_CRW_disarm_payload_deployment", terminated by a newline (\n) character. Do not include quotes
- 45 If E-match does not fire, test team decides whether to proceed to Hang Fire or continue with Backup E-Match Test

BACKUP E-MATCH TEST

- 46 Verify it has been at least 2 minutes since Primary E-match Test
- 47 Repeat steps 38-40 to re-arm controller
- 48 All personnel move at least 10ft away from system
- 49 From the serial terminal, send text "UAH_CRW_deploy_payload_backup", terminated by a newline (\n) character. Do not include quotes
- 50 Observe automatic sequence. Sequence concludes when payload stops beeping and changes to a 1 Hz red LED blink rate
 - If payload has not stopped beeping
 - From the serial terminal, send text "UAH_CRW_disarm_payload_deployment", terminated by a newline (\n) character. Do not include quotes

SAFING AND CLEANUP

- 51 Set the deployment controller to off using the power switch
- 52 Verify red LED on deployment controller is off
- 53 Remove E-matches from screw terminals
- 54 Remove batteries



- 55 Return barricades to their storage location
- 56 Warning light should be turned to Green.

ADMINISTRATIVE & DOCUMENTATION TASKS

- 57 Upon completion, the SOP needs to be signed by the participating Red Team members, scanned, and provided to the Safety Officer.

HANG FIRE

- 58 Verify no tone and 1 Hz blink rate
 - 59 If payload has not stopped beeping
 - From the serial terminal, send text "UAH_CRW_disarm_payload_deployment", terminated by a newline (\n) character. Do not include quotes
 - 60 Wait 2 minutes or until green LED dims, whichever is first
 - Lit green LED indicates capacitors are charged.*
 - 61 Approach and turn power switch
 - 62 Remove CR123 batteries
 - 63 Debug
-



SECTION III. APPENDICES.

APPENDIX A. Cross Referenced Procedures

The following procedures are referenced in this SOP and are required for verification purposes.

#	SOP Doc #	Description
1	PRC-SOP-001	UAH Propulsion Research Center – Facility Usage Policy, 1-Apr-2012.
2	PRC-SOP-002	PRC Safety Plan
3	CRW-RAC	Charger Rocket Works Risk and Hazard Assessment



APPENDIX B. Risk Assessment

RAC				
Probability Level	Severity Level			
	1 Catastrophic	2 Critical	3 Marginal	4 Negligible
A – Highly Probable	1A	2A	3A	4A
B – Likely	1B	2B	3B	4B
C – Moderate	1C	2C	3C	4C
D – Unlikely	1D	2D	3D	4D
E – Improbable	1E	2E	3E	4E

Severity Level	
Description	Criteria
1 – Catastrophic	Loss of life or permanent injury, irreparable major damage to facilities or hardware, complete project failure.
2 – Critical	Severe personal injury, significant damage to hardware or facilities, significant impact on overall schedule.
3 – Marginal	Minor personal injury, reparable damage to facilities or hardware, significant impact on immediate schedule.
4 – Negligible	Minor personal injury, little to no damage to hardware, little impact on immediate schedule.

Probability Level		
Description	Criteria	
	Qualitative	Quantitative
A – Highly Probable	Highly expected to occur or to occur frequently during project duration.	85% < Probability
B – Likely	Expected to occur or to occur several times during project duration.	50% < Probability < 85%
C – Moderate	Potential to occur multiple times during project duration.	25% < Probability < 50%
D – Unlikely	Remote potential to occur with exception of rare occasion during project duration.	1% < Probability < 25%
E – Improbable	Highly unexpected to occur during project duration.	Probability < 1%



Hazard Assessment and Mitigation						
E-Match Combustion						
Hazard	Cause	Effect	Pre-RAC	Mitigation	Verification	Post-RAC
Fire	Flammable material near E-match during ignition, inadvertent ignition of E-Match.	Damage to facility and personnel	3D	<ul style="list-style-type: none"> Red Team will be trained on fire procedures. Flammable material will be kept away from test area. Test operators will wear proper PPE. E-matches are placed in centrifuge cups to contain debris. 	<ul style="list-style-type: none"> Safety Briefings and PRC training mandatory for all test operators. SOP step 7 SOP Section 6 SOP step 31 	3E
Burns	Fire from ignition of E-match, inadvertent ignition of E-Match.	Personnel injury	3C	<ul style="list-style-type: none"> Test operators will wear proper PPE. Test operators will follow SOP guidelines by staying safe distance away from system during test. 	<ul style="list-style-type: none"> SOP Section 6 SOP steps 35, 37, 41, 48 	3E



APPENDIX C. UAH PRC Facility Usage Policy

UAH Propulsion Research Center Facility Usage Policy

The Propulsion Research Center (PRC) conducts research, produces publications, and mentors students in advanced propulsion technologies and their applications. The PRC connects the academic research community and propulsion community through interdisciplinary collaboration.

The Propulsion Research Center laboratories were established to provide UAH faculty, staff, and students, state-of-the-art facilities for conducting basic and applied research on propulsion systems and related sciences. The center was established to provide students a "hands-on" education in propulsion. The facilities may be used for sponsored research projects, PRC staff and Graduate Student research projects, and approved UAH undergraduate research projects. Use of the facility requires prior written approval of the PRC Director. The Propulsion Research Center acknowledges that hazards are inherent to the nature of the research conducted in the facilities and requires strict adherence to facility rules and protocols for anyone engaged in research in the PRC laboratories.

PRC facility protocol is as follows:

- 1) All PRC Test operations are under the authority of the PRC Director and UAH campus safety practices.
- 2) All personnel involved in testing are UAH employees, UAH students under PRC supervision, or customers with an active contract with UAH.
- 3) All tests involving pressures over 100 psi, high voltage, combustion, or other sources of possibly injury require a Standard Operating Procedure (SOP), reviewed and signed by the test team, and approved by the PRC Director.
- 4) The tests are conducted by a designated Red Team who has at least one UAH staff member and has at least two members who are Red Cross Safety and CPR/AED Certified.
- 5) After any major test anomaly, all PRC test operations are automatically suspended until a determination of the basic cause of the incident is determined and all active SOPs are reviewed in light of the findings of the incident before resuming testing.

Handwritten signature of Robert Frederick in black ink.

Robert Frederick
Director PRC

4/1/2012



APPENDIX D. Emergency Contact Information

In the event of an emergency, respond in accordance with off-nominal procedures defined in this SOP and in accordance with the appropriate section in the UAH PRC Safety Program dated 22-Feb-2013.

Emergency contact numbers are provided below.

Police	911
Fire Department	(256) 824-6911
Hazardous Materials Incident	(6911 from campus phone)
Utility Failure	
Tony Hall	
	Office : (256) 824-2887
David Lineberry	
	Office : (256) 824-2888
	Cell: (256) 348-8978
Robert Frederick	
	Office : (256) 824-7200
	Cell: (256) 503-4909
PRC Main Office	(256) 824-7209
High Pressure Lab Phone	(256) 824-6031
JRC Test Stand	(256) 824-2857
Kristy Olive/OEHS (Office of Environmental Health and Safety)	(256) 824-2171 (256) 335-3425
UAH Campus Police Department	
	(256) 824-6911
Huntsville Police Department	
	(256) 722-7100
Madison County Sheriff's Office	
	(256) 722-7181
Alabama State Troopers	
	(334) 242-4371
Huntsville Hospital	
	(256) 265-1000

In the event of a non-emergency reportable incident call the numbers below in the following order.

- 1. Dr. Robert Frederick (Dr. David Lineberry as an alternate)**
Office: (256) 824-7200
Cell: (256) 503-4909
- 2. UAH Police (Non-Emergency)**
(256) 824-6596
6596 (from campus phone)