



UAH Propulsion Research Center  
 OPERATING PROCEDURE FOR:  
***UAV Flight Range Demonstration***

SOP #: PRC-SOP-USLI-023

Revision: A

Version: 0

Test Location:

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 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 USLI</i>	<i>See Signature Page</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	N/A			



**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.

**Connor Gisburne:** \_\_\_\_\_ **Date:** \_\_\_\_\_  
**Author**

**Colton Connor:** \_\_\_\_\_ **Date:** \_\_\_\_\_  
**Payload Lead**

**Hope Cash:** \_\_\_\_\_ **Date:** \_\_\_\_\_  
**Safety Officer**

**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		
Elena Pradhan	MAE 491 Student	10/5/2018	Sept 2018		
Hope Cash	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 UAV system can fly a minimum of XX miles. Success will be defined as the UAV successfully flying XX miles then going through its landing sequence upon depleting its batteries.

### **2. Test Location**

The flight range demonstration will take place at XX. For testing, personnel must be at least 10ft away from the test article, and must keep line of sight with the UAV at all times.

### **3. Roles and Responsibilities**

This procedure requires a minimum of 2 test operators from the Payload Team. PRC staff or mentor must be present for supervision. 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 UAV System		Mini-USB cable
	12V power supply		Laptop with Mission Planner
	Grandstream video converter		Holybro Telemetry receiver
	2 Charged LiPo batteries		Stopwatch
	UAV Controller		Lumenier RX5GDR Diversity Receiver
	Work Gloves		Biquad Antenna
	Safety glasses		Dipole Antenna
	LiPo Voltage checker		



## 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 **Make sure all personnel are wearing the proper PPE, e.g., safety glasses etc.**
- 4 Setup camera to record test (optional).
- 5 **Remove any unnecessary equipment from test area**

### UAV SETUP

- 6 Verify LiPo batteries disconnected
- 7 Verify personnel are wearing safety glasses
- 8 Verify UAV system is properly assembled
- 9 Check LiPo Voltages  
*Battery 1: Cell 1: \_\_\_\_\_ Cell 2: \_\_\_\_\_ Cell 3: \_\_\_\_\_*
- 10 Install UAV propellers according to labels on arms.
- 11 Verify arms are locked in flight orientation
- 12 Test conductor put on work gloves.
- 13 Connect LiPo battery on the UAV system to the UAV electronics
- 14 Verify battery is securely connected.
- 15 Verify power switch turned to ON
- 16 Confirm Startup OK tune
- 17 Verify UAV is ready for flight

*Test conductor can remove work gloves*

### SOFTWARE VERIFICATION/SETUP

- 18 Power on laptop
- 19 Open Mission Planner Ground Station Software



- 20 Select COM port of antenna input
- 21 Set baud rate to 57600
- 22 Verify the UAV is properly transmitting telemetry via GPS 3D fix
- 23 Verify UAV controller is properly functioning via test input to solenoid

### **FLIGHT SEQUENCE**

- 24 Verify all personnel are a minimum of 10 ft from the UAV system
- 25 Using UAV controller, arm UAV
- 26 Using UAV controller, lift off to 50 ft altitude
- 27 In Mission Planner, input 4 GPS waypoints
- 28 Simultaneously, begin timing the length of the flight using the stopwatch
- 29 Begin counting the number of times the UAV can complete the designated flight circuit
- 30 Wait until UAV depletes batteries and runs automated landing sequence
- 31 Simultaneously, stop recording UAV hover time
- 32 Record measured flight time

*Flight time:* \_\_\_\_\_

- 33 Record number of laps around the circuit

*Number of laps:* \_\_\_\_\_

### **SAFING AND CLEANUP**

- 34 Power off UAV system
- 35 Test conductor put on work gloves
- 36 Disconnect battery
- 37 Remove propellers

*Test conductor can remove work gloves*

### **ADMINISTRATIVE & DOCUMENTATION TASKS**

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





## 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						
UAV Payload						
Hazard	Cause	Effect	Pre-RAC	Mitigation	Verification	Post-RAC
Power Loss to one or more systems	Battery failure, voltage spike, power system failure.	Could prevent the UAV from flying causing damage to UAV	2D	<ol style="list-style-type: none"> <li>1. Design robust battery retention.</li> <li>2. Ensure batteries are fully charged prior to test.</li> <li>3. Padding around UAV flight area ensure soft impact.</li> </ol>	<ol style="list-style-type: none"> <li>1. SOP Step XX</li> <li>2. SOP Step XX</li> <li>3. SOP Step XX</li> </ol>	2E
Signal Loss - Telemetry	Power loss to receiver/transceiver.	Loss on data, loss of UAV control resulting in mission failure	2C	<ol style="list-style-type: none"> <li>1. Tether UAV during test to prevent uncontrolled flight.</li> </ol>	<ol style="list-style-type: none"> <li>1. SOP Steps XX</li> </ol>	2E
Cuts	Spinning propellers come in contact with personnel	Personnel injury.	3B	<ol style="list-style-type: none"> <li>1. Barricades will be placed around the UAV during operation.</li> <li>2. Gloves will be worn when handling UAV once batteries have been connected.</li> <li>3. Only trained Red Team members will conduct test procedures.</li> </ol>	<ol style="list-style-type: none"> <li>1. SOP step XX</li> <li>2. SOP steps XX</li> <li>3. SOP Section <i>Authorized Red Team Members</i></li> </ol>	3E
LiPo battery explosion	Overcharging of battery, over discharging of batteries, using hot batteries, improper storage.	Fire, release of toxic vapors	2D	<ol style="list-style-type: none"> <li>1. Batteries will be charged in an approved LiPo charging bag.</li> <li>2. Batteries will be recharged once depleted.</li> </ol>	<ol style="list-style-type: none"> <li>1. Safety Briefing 7</li> <li>2. Appendix F</li> </ol>	3D



LiPo Battery swelling, bursting	Overcharging of battery, over discharging of batteries, using hot batteries, improper storage.	Fire, release of toxic vapors	2D	<ol style="list-style-type: none"> <li>1. Batteries will be charged in an approved LiPo charging bag.</li> <li>2. Batteries will be recharged once depleted.</li> </ol>	<ol style="list-style-type: none"> <li>1. Safety Briefing 7</li> <li>2. Appendix F</li> </ol>	3D
Fire	LiPo battery explosion	Burns, damage to facilities or personnel.	3C	<ol style="list-style-type: none"> <li>1. Test operators will wear proper PPE.</li> <li>2. Test operators will follow SOP guidelines by staying safe distance away from system during test.</li> <li>3. Fire extinguisher will be available in test area.</li> </ol>	<ol style="list-style-type: none"> <li>1. SOP Section 6</li> <li>2. SOP step XX</li> <li>3. SOP step X</li> </ol>	3E
Inhalation of toxic vapors	LiPo battery explosion, releasing of dangerous contents	Respiratory irritation	3D	<ol style="list-style-type: none"> <li>1. Batteries will be charged in approved LiPo charging bag.</li> <li>2. Vacate area until fumes have dissipated.</li> </ol>	<ol style="list-style-type: none"> <li>1. Safety Briefing 7</li> <li>2. Appendix F</li> </ol>	4D
Uncontrolled UAV	Unstable flight, component failure, improper control	Personnel injury, facility/hardware damage, flying debris	2C	<ol style="list-style-type: none"> <li>1. Barricaded flight area</li> <li>2. Padded flight area</li> <li>3. Tethered flight</li> <li>4. Remote disarm</li> </ol>	<ol style="list-style-type: none"> <li>1. SOP Step XX</li> <li>2. SOP Step XX</li> <li>3. SOP Steps XX</li> <li>4. SOP Steps XX</li> </ol>	3C



## 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	
<b>Tony Hall</b>	
	Office : (256) 824-2887
<b>David Lineberry</b>	
	Office : (256) 824-2888
	Cell: (256) 348-8978
<b>Robert Frederick</b>	
	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
<b>UAH Campus Police Department</b>	
	(256) 824-6911
<b>Huntsville Police Department</b>	
	(256) 722-7100
<b>Madison County Sheriff's Office</b>	
	(256) 722-7181
<b>Alabama State Troopers</b>	
	(334) 242-4371
<b>Huntsville Hospital</b>	
	(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)**