UAH Propulsion Research Center

OPERATING PROCEDURE FOR:

Full-Scale Rocket Prep and Launch

SOP #: PRC–SOP–*USLI-021*

Revision: *A*

Version: *1*

Test Location: *Launch Field*

Test Date: _____

Test Team

NAME	ROLE

This Procedure Contains the following Hazards

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

For PRC Internal Use Only

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	***New SOP, To update Red Team and Template, for 2018-2019 USLI***	***See Signature Page***	***110***
1	***Update SOP to include full UAV integration steps, update Red Team, for 2018-2019 USLI***	***See Signature Page***	***5***

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.

Hope Cash: _____ Date: _____
Author

William Hankins: _____ Date: _____
Vehicle Lead

Jade Kirkwood: _____ Date: _____
Vehicle Safety Lead

Colton Connor: _____ Date: _____
Payload 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		
Hope Cash	MAE 491 Student	10/5/2018	Sept 2018		
William Hankins	MAE 491 Student	10/4/2018	Sept 2018		
Kyle DeGreen	MAE 491 Student	10/5/2018	Sept 2018		
Colton Connor	MAE 491 Student	10/5/2018	Sept 2018		
Daniel Corey	MAE 491 Student	8/14/2018	Sept 2018		
Elena Pradhan	MAE 491 Student	10/5/2018	Sept 2018		
Zachary Ruta	MAE 491 Student	10/4/2018	Sept 2018		
Tanner Schmitt	MAE 491 Student	10/5/2018	Sept 2018		
Bao Ha	GTA Mentor	10/13/2017	Jan 2019		

DECLARATIONS.

Objective

This SOP establishes procedures and defines safety precautions that will be used for assembly of a high powered rocket. The procedure includes preparation and installation of black powder charges for deployment of the recovery systems and loading of the solid rocket motor.

Test Location

This will occur at a NAR/TRA organized launch field. This provides a secured and controlled access area. Assembly operations, up to the addition of energetic materials to the rocket, may be carried out either at a launch field or prior to arrival at the launch field. Black powder charge loading and solid rocket propellant loading may only be carried out at the launch field when testing is imminent. Handling of energetics will be carried out by the NAR/TRA certified Team Mentor.

Roles and Responsibilities

This procedure requires a minimum of 2 test operators, but may be conducted by up to 5 persons. Operations involving black powder or solid rocket propellant will be conducted under by the Team Mentor. One of the operators will be designated as the Safety Monitor and will read procedures during testing and ensure all steps are followed or any deviations are documented. The Safety Monitor will be identified on the front page of the procedure. Two members must also be involved when moving the rocket, one for handling and the other to notify any bystanders of the rocket's presence.

Observer Policy

Observers will be allowed as authorized by launch field guidelines. Observers must remain safe distances from energetic materials including black powder and solid rocket propellant.

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. 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.

Personal Protective Equipment (PPE)

Test personnel must wear safety glasses at all times during test operations. Long pants and closed toed shoes are also required for testing. When handling Black Powder, nitrile gloves must be worn. Nearby Fire Extinguisher must be on hand or locations identified prior to testing.

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.

PRE-TRAVEL PREPARATION PROCEDURES

PREPARATION OF BLACK POWDER CHARGES

1. **Inform all observers of emergency exits and other pertinent safety information.**
2. If preparing charges at the JRC, identify nearest AED location to team and observers.
3. Place all jewelry and electronic devices, tablets, and radios in an approved location.
4. Place Cell Phones in "airplane mode"
5. **Make sure all personnel are wearing the proper PPE, e.g., safety glasses, goggles, or face shield, hearing protection (if needed).**
6. If testing at the JRC,
    - If testing at the JRC, warning light should be turned to YELLOW during the set-up procedure and throughout the experiment.

⚠ MUST WEAR NITRILE GLOVES WHILE HANDLING BLACK POWDER

⚠ TEAM MENTOR OR TEAM PRC FACULTY ONLY HANDLE BLACK POWDER

7. Remove black powder from designated container.
8. Use the following steps to prepare the ejection charges with black powder ONE AT A TIME.

	Main Primary	Main Backup	Drogue Primary	Drogue Backup	Deploy Primary	Deploy Backup
9. Inspect E-Match to be used for ejection charge for frayed wires						
10. Cut E-match to size and strip ends.						
11. Short ends of e-match by twisting leads together.						
12. Measure specified amount of black powder to be used in a volumetric measuring device						
13. Transfer to flight charge container						
14. Close/seal container as designed						
15. Label charge with painters tape Main Primary, Main Backup, Drogue Primary, or Drogue Backup as appropriate, and include the						

charge size						
16. Record the volume of the black powder in the cells on this sheet						
17. Place Loaded Ejection charge in Day box						
18. Repeat from Step 9 until all charges are prepared						

19. Prepare rocket for transport to launch field
20. Check Stratologger configuration
21. Verify that the following materials have been packed for transport:

	Blue/Black nosecone		Main parachute Assembly (parachute, shock cord, nomex sheets (2) and sleeve, quick links)
	Forward airframe body tube		Nosecone switch keys
	Lower Airframe body tube		Altimeter bay switch keys
	Computer with Simulation Software and Serial Terminal Program		Stratologger Manual
	Stratologger Download Chip/wire		Laptop with Stratologger software
	Avionics Bay/Coupler (fully assembled)		Day Box containing: Motor and Black Powder L1420 Motor, Reload kit, igniters, E-matches (6)
	Motor Case (75/5120)		Motor Case Seal Disk
	Motor Case Aft Closure		Motor Forward Closure (Plugged)
	Main Primary Ejection Charge		Drogue Primary Ejection Charge
	Main Backup Ejection Charge		Drogue Backup Ejection Charge
	New, unused 9V batteries (6)		Laptop with X-CTU
	New, unused CR123 Batteries (6)		Ground station XBee, labeled
	Rocket Tracker		Yagi antenna, RPSMA connector
	Door-latch solenoid		Red XBee explorer (2)
	Deployment ground system X-bee		Mini USB cable (2)

	Latch detect switch (leaf-lever switch)		Micro USB cable
	(Payload deployment controller) Circuit board		2 E-matches for payload
	Power switch (screw switch)		Capacitor bank
	All screws for vehicle in closeable containers		Zipties
	Scissors		10.10 rail button
	Hand drill		Channel lock
	Hand drill bits		Wire strippers with bolt trimmers
	Hammer		#2 Phillips screwdriver
	6” calipers		7/16” wrench for coupler
	Gray English allen wrench set		¼” nut driver
	Regular needle nose pliers		Tape measure
	Tiny Flat Head Screwdriver for Stratologgers		Extra long needle nose pliers
	Phillips head for Stratologger mounting screws		Flat Head Screwdriver for Bulkhead E-Match terminals
	Adjustable wrench		Electrical tape
	Multimeter (with probes)		Gorilla tape
	Scale for weighing rocket at launch field		Painter’s/masking tape
	Dog barf		Shear Pins (4-40 Nylon in closeable container
	Simple Green		Hand wipes
	Ethanol alcohol		At least 2 printed copies of this SOP
	Nitrile Gloves		Cleaning brush
	Table (2)		Paper towels
	Assorted stranded wire		Trash bags
	Rocket stands		Safety Glasses
	First Aid Kit		Pop-up awning
	Tarp		Clamps

AT FIELD

ALL ASSEMBLY PROCEDURES WILL BE CONDUCTED BY RED TEAM MEMBERS ONLY

ALL PERSONNEL WILL WEAR SAFETY GLASSES THROUGHOUT THESE PROCEDURES

UPPER AIRFRAME ASSEMBLY

NOSECONE CHECKLIST (CONDUCTED IN PARALLEL WITH UAV AND PISTON PREP)

22. Remove nosecone bulkhead and assembly from nosecone
23. Use Multimeter to test voltage of new CR123 battery for tracker

Voltage measured: _____

The CR123 should measure 3V or greater, anything less is NOT acceptable for flight.

Data may not be received from tracker if there is insufficient voltage.

24. Install new CR123 battery into GPS Tracker
25. Zip-tie CR123 battery to bracket, avoiding GPS with zip-tie
26. Verify XBee ziptied to tracker
27. Verify tracker is ON
28. Verify tracker connected to tracker power switch
29. Verify Raven's positive power wire connected to Raven power switch
30. Use Multimeter to test voltage of new 9V battery for Raven

Voltage measured: _____

The battery must measure 9V or greater, anything less is NOT acceptable for flight.

Data may not be received from Raven if there is insufficient voltage.

31. Attach Raven battery to nosecone bracket
32. Ziptie battery to Raven bracket

Avoid Raven with ziptie. Failing to ziptie battery could result in loss of power to Raven.

33. Verify tracker is attached to the nosecone bulkhead
34. Use Multimeter to test voltage of LiPo battery

Voltage measured: _____

LiPo must read greater than 4V, anything less is NOT acceptable for flight.

No data will be received from data logger if insufficient voltage.

35. Insert microSD card into data logger
36. Install data logger SD card retention screw
37. Connect LiPo battery to gray terminal in data logger

38. Verify 1 Hz blue LED blinking on data logger
39. Turn OFF Raven and tracker
40. Install nosecone over nosecone bulkhead
41. Secure nosecone to bulkhead using two (2) ¼-20 nuts

Verification Signatures:

Vehicle Red Team Member	**Safety Monitor**

UAV Prep Checklist (Conducted in Parallel with Nosecone and Piston Checklists)

42. Measure LiPo cell voltages with voltage checker

    Battery voltage must be at least 12.4 V

43. Record LiPo cell voltages

    Cell 1: _____ V. Cell 2: _____ V. Cell 3: _____ V

44. Verify/remove UAV propellers
45. Power on UAV ground station laptop
46. Insert microSD card into laptop
47. Verify/empty microSD card

    Card must have at least 1 GB of free space

48. Insert microSD card into UAV flight computer
49. Insert battery into UAV
50. Secure battery to mounting bracket using two (2) zip tie loops
51. Tug on battery/verify securely retained
52. Connect UAV power plug to LiPo battery
53. Verify startup ok tune emitted by UAV
54. Open Mission Planner ground station software
55. Select COM port of telemetry radio
56. Set baud rate to 57600
57. Press “connect” button in Mission Planner
58. Verify the UAV has a 3D GPS fix
59. Verify battery voltage displayed in Mission Planner is within 0.05 V of checked voltage
60. Depress blue button on UAV controller to retract solenoid
61. Insert beacon into UAV beacon compartment
62. Release blue button on UAV controller
63. Tug on beacon/verify beacon retained
64. Verify no flagged issues on Mission Planner “Pre-Flight” tab
65. Gently shake assembled UAV/verify no loose mechanical or electrical connections
66. Disconnect LiPo battery from UAV power
67. Install 2x CCW and 2x CW propellers onto the UAV

    Direction labels on propellers must match labels on UAV arms

Verification Signatures:

Payload Red Team Member **Safety Monitor**

Piston Checklist (Conducted in Parallel with Nosecone and UAV Checklists)

Steps 68 – 85 may be conducted before departure to the launch field. Step 85 is waived if these steps are conducted at launch field

68. Remove deployment circuit board from enclosure
69. Check CR123A (x2) voltages

    Anything less than 3.0 V is not acceptable for flight

    Battery 1: _____ V. Battery 2: _____ V
70. Install batteries into deployment circuit board
71. Zip-tie batteries around circuit board
72. Install Plug 1 XBee radio (with wire antenna) into deployment circuit board

    XBee labeled "Deploy"
73. Zip-tie radio around circuit board
74. Plug the door latch solenoid into header LATCH on the deployment circuit board
75. Plug the capacitor bank into header CAP on the deployment circuit board
76. Plug the power switch into header PWR SW on the deployment circuit board
77. Plug the latch detect switch into header DETECT on the deployment circuit board
78. Verify/set SW3 on the deployment circuit board to the ON position
79. Install cover over circuit board enclosure and secure to bulkhead
80. Tape over wire ports on circuit board enclosure
81. Secure any loose wires with tape or zip ties
82. Verify all wiring is clear of the retention latch and beam
83. Verify/set deployment controller to OFF using power switch
84. Verify no beeping emitted from deployment controller
85. Place a label over the power switch access port reading "Prepared <DATE> <TIME>. Do not remove"

Verification Signatures:

Payload Red Team Member **Safety Monitor**

All steps following this are to be completed on the flight line ONLY

86. Remove the label placed across the power switch in step 85, if applicable

SOFTWARE VERIFICATION/SETUP

87. Connect XBee and antenna to laptop computer

    XBee is labeled "Deploy GS"

88. Open serial terminal on laptop

89. Connect serial terminal to appropriate COM port

90. Set serial terminal baud rate to 115200 baud

91. Verify/set deployment controller to ON using power switch

92. Verify buzzer beeping at approximately 1 Hz

93. Send text "UAH_CRW_verify_communications", terminated by a newline (\n) character. Do not include quotes

94. Verify board emits 3 short beeps, 3 long beeps, 3 short beeps (SOS)

95. Set deployment controller to OFF using power switch

Failing to set controller to OFF could result in unintentional detonation during charge installation

E-MATCH INSTALLATION

The Following Steps must be performed by the Team Mentor

SAFETY GLASSES MUST BE WORN WHILE INSTALLING BLACK POWDER CHARGES

96. Ensure deployment controller is off

Failure to do so may result in unintentional detonation

97. Verify no sound from deployment controller circuit board

    Any sound provides an indication that the circuit is live.

98. Confirm with Mentor that rocket is ready for energetics

99. Identify primary and backup terminals on deployment electronics enclosure

100. Retrieve charges from Day Box

_____g Payload deployment Primary Charge Vol

_____g Payload deployment Charge Vol

101. Connect Ejection Charge (x2) e-match leads to terminals on deployment electronics enclosure. Each terminal block is used for a separate charge and the terminal blocks have been labeled

102. Give ejection charge lead wires a slight tug to ensure they are firmly connected to the terminal blocks

⚠ *Failure to ensure secure connection may result in deployment failure*

103. Place charge in charge well and place painter's tape over well

Verification Signatures:

Payload Red Team Member **Safety Monitor**

Payload Integration Checklist

104. Test conductor(s) put on work gloves

105. Connect LiPo battery to UAV power

106. Verify startup ok tune emitted by UAV

107. Lower UAV onto deployment sheath vertical posts

108. Fold UAV arms inwards until UAV powers off

109. Fold deployment sheath inner flap over UAV and tuck under

110. Roll deployment sheath upper flap around sheath

111. Install 1x pipe clamp around the center of the deployment sheath to keep sheath rolled

112. Install upper airframe bulkhead into piston

113. Verify latch clicks during installation

⚠ *Failure of latch click may result in loss of system during flight*

114. Tug upper airframe bulkhead to verify it does not separate from piston

115. Align clocking marks on upper airframe and piston assembly

116. Insert piston and lower half of sheath into airframe

117. Remove pipe clamp from deployment sheath

118. Insert remainder of sheath and nosecone into airframe

119. Secure upper airframe bulkhead in body tube using six (6) ½" long torx drive #4-40 screws

Verification Signatures:

Payload Red Team Member **Safety Monitor**

COUPLER CHECKLIST

(Conducted in Parallel with Upper Airframe Assembly: UAV/Piston/Payload Integration)

120. Verify that no black powder charges are attached to the terminal blocks on the AV Bay bulkheads

121. Use Multimeter to verify voltage of new 9V battery for Stratologger (x2)

Voltage measured: _____ Primary Stratologger

Voltage measured: _____ Secondary Stratologger

If the batteries do not measure 9V or greater, they are NOT acceptable for flight

⚠ *Recovery failure may occur if there is insufficient voltage*

122. Unscrew top coupler bulkhead

123. Remove top bulkhead from coupler and disconnect wires

124. Disconnect key switches

125. Install new 9V batteries into avionics sled (x2)

126. Ziptie 9V batteries to battery bracket

127. Tug Stratologger wires to ensure they are firmly connected

128. Slide lower bulkhead and avionics sled partially back into coupler

129. Connect switches

130. Switch on Stratologgers to check functionality one at a time

131. Beep count:

- 3 beeps
- Main deployment altitude
- Optional apogee delay indicated by 1 second tone (backup only)
- Last flight apogee
- 2 or 3 digit number for battery voltage
- Continuity beeps

132. Insert lower coupler bulkhead into body tube

133. Connect upper bulkhead to wire
134. Screw upper bulkhead onto coupler
135. Duct tape/secure cotter pin
136. Turn off Stratologger

⚠ *Failing to turn off Stratologgers may result in unintentional detonation during charge installation*

Verification Signatures:

Vehicle Red Team Member **Safety Monitor**

LOWER AIRFRAME ASSEMBLY

(Conducted in Parallel with Upper Airframe Assembly: UAV/Piston/Payload Integration)

137. Remove the motor retainer
138. Verify/tighten all external bolts (16)

Verification Signatures:

Vehicle Red Team Member **Safety Monitor**

⚠ **DO NOT CONTINUE UNTIL UPPER AIRFRAME ASSEMBLY, COUPLER CHECKLIST, AND LOWER AIRFRAME ASSEMBLY SECTIONS ARE COMPLETE**

RECOVERY CHECKLIST

DROGUE INSTALLATION (UPPER AIRFRAME)

CONDUCTED IN PARALLEL WITH MAIN INSTALLATION (LOWER AIRFRAME)

139. Verify/Detangle Drogue Parachute Harness
140. Inspect Drogue Parachute Harness for damage, tears, deterioration
141. Verify Drogue Parachute Recovery harness is attached to the upper airframe bulkhead

⚠ *Failing to attach recovery harness may result in recovery failure*

142. Verify/Attach Drogue Parachute to Drogue Parachute Harness
143. Verify that Drogue parachute will CLEAR ROCKET WHEN RECOVERY HARNESS IS TAUT (unpack)
144. Verify duct tape covers shock cord at lip of body tube

⚠ *Failing to cover shock cord at lip could result in zipper through body tube*

145. Verify Shock Cord Nomex Cloth is attached to the Drogue Parachute Harness
146. Verify that the Shock Cord Nomex Cloth cannot slide freely on the recovery harness
147. Verify Parachute Nomex Cloth is attached to the Drogue Parachute Harness
148. Verify that the Parachute Nomex Cloth cannot slide freely on the recovery harness
149. Verify/Attach the Drogue Parachute recovery harness is connected to eyebolt on the upper coupler bulkhead

⚠ *Failing to attach recovery harness may result in recovery failure*

150. Fold the Drogue parachute in accordance with method used for successful Ejection Charge Test
151. Wrap the Drogue parachute in the Parachute Nomex sheet attached to the recovery harness
152. Z-Fold 5ft sections of the recovery harness and secure folds with a rubber band
153. Insert recovery harness on the airframe side of the parachute into upper airframe body tube longitudinally, starting with the outside edge and working in
154. Verify no transport painter's tape is wrapped around Drogue/Nomex

⚠ *Failure to remove transport painter's tape may result in recovery failure*

155. Insert folded Drogue/Nomex into upper airframe with Nomex facing towards coupler
156. Insert remaining unprotected shock cord on coupler side of parachute and cover with Shock Cord Nomex
157. Coil Nomex Sleeve shock cord around the edges of body tube

Verification Signatures:

Vehicle Red Team Member **Safety Monitor**

MAIN INSTALLATION (LOWER AIRFRAME)
CONDUCTED IN PARALLEL WITH DROGUE INSTALLATION (UPPER AIRFRAME)

158. Verify/Detangle Main Parachute Harness
159. Inspect Drogue Parachute Harness for damage, tears, deterioration
160. Verify Main Parachute Recovery harness is attached to the lower airframe bulkhead

Failing to attach recovery harness may result in recovery failure

161. Verify/Attach Main Parachute to Main Parachute Harness
162. Verify that Main parachute will CLEAR ROCKET WHEN RECOVERY HARNESS IS TAUT (unpack)
163. Verify duct tape covers shock cord at lip of body tube

Failing to cover shock cord at lip could result in zipper through body tube

164. Verify Shock Cord Nomex Cloth is attached to the Main Parachute Harness
165. Verify that the Shock Cord Nomex Cloth cannot slide freely on the recovery harness
166. Verify Parachute Nomex Cloth is attached to the Main Parachute Harness
167. Verify that the Parachute Nomex Cloth cannot slide freely on the recovery harness
168. Verify/Attach that the Main Parachute recovery harness is connected to eyebolt on the lower coupler bulkhead

Failing to attach recovery harness may result in recovery failure

169. Fold the Main parachute in accordance with method used for successful Ejection Charge Test
170. Wrap the Main parachute and unprotected line on the coupler side in the Parachute Nomex sheet attached to the recovery harness
171. Z-Fold 5ft sections of the recovery harness and secure folds with a rubber band
172. Insert recovery harness on the airframe side of the parachute into lower airframe body tube longitudinally, starting with the outside edge and working in
173. Verify no transport painter's tape is wrapped around Main/Nomex

Failure to remove transport painter's tape may result in recovery failure

174. Insert folded Main/Nomex into lower airframe with Nomex facing towards coupler
175. Coil Nomex Sleeve shock cord around the edges of body tube

Verification Signatures:

Vehicle Red Team Member _____

Safety Monitor _____

DO NOT CONTINUE UNTIL RECOVERY CHECKLIST IS COMPLETE

EJECTION CHARGE INSTALLATION

The Following Steps must be performed by the Team Mentor

SAFETY GLASSES MUST BE WORN WHILE INSTALLING BLACK POWDER CHARGES

176. Ensure Stratologgers are off

Failure to do so may result in unintentional detonation

177. Confirm with Mentor that rocket is ready for energetics
178. Identify primary and backup terminals on coupler for both main and drogue
179. Retrieve Drogue charges from Day Box

_____g Drogue Primary Charge Vol

_____g Drogue Secondary Charge Vol

180. Connect Ejection Charge (x2) e-match leads to terminals on upper coupler bulkhead. Each terminal block is used for a separate charge and the terminal blocks have been labeled.
181. Give Drogue Ejection Charge lead wires a slight tug to ensure they are firmly connected to the Terminal Blocks

Failure to ensure secure connection may result in recovery failure

182. Place charge in charge well and place painter's tape over well
183. Insert dog barf in upper airframe
184. Attach upper airframe to coupler
185. Insert 2 new shear pins (nylon #4-40)

Failure to use NEW shear pins may result in premature recovery separation

186. Ensure Stratologgers are off

Failure to do so may result in unintentional detonation

187. Retrieve Main charges from Day Box

_____g Main Primary Charge Vol
_____g Main Secondary Charge Vol

188. Connect Ejection Charge (x2) e-match leads to terminals on lower coupler bulkhead. Each terminal block is used for a separate charge, and the terminal blocks have been labeled.
189. Give Main Ejection Charge lead wires a slight tug to ensure they are firmly connected to the Terminal Blocks

Failure to ensure secure connection may result in recovery failure

190. Place charge in charge well and place painter's tape over well
191. Insert dog barf into lower airframe (2 Bao hands)
192. Attach lower airframe to coupler
193. Insert 8 new shear pins (nylon #4-40)

⚠ *Failure to use NEW shear pins may result in premature recovery separation*

Verification Signatures:

Red Team Member **Safety Officer**

Red Team Member

MOTOR INSTALLATION

The Following Steps must be performed by the Team Mentor

⚠ SAFETY GLASSES MUST BE WORN WHILE INSTALLING MOTOR

NOTE: ALL PERSONNEL ARE REQUIRED TO COMPLY WITH PPE REQUIREMENTS SPECIFIED BY MANUFACTURER

194. Assemble motor per manufacturer instructions.
195. NAR/TRA Mentor install motor case into lower airframe
196. Install motor retainer with 2 4-40 bolts

Verification Signatures:

Team Mentor **Safety Officer**

FINAL CHECKOUT

TWO PEOPLE ARE REQUIRED FOR MOVING ROCKET - AIM ROCKET AWAY FROM OBSERVERS

197. Measure length of fully assembled rocket

Length: _____

198. Perform Shake Test to ensure that rocket components are secured and that the rocket will not drag separate in flight
199. Balance rocket to measure the CG location
200. Mark CG location on rocket

201. Weigh Fully Assembled Rocket

    Weight: _____

202. Record CP location

    CP: _____

203. Ensure that this CG location is at least 2 body diameters (12 inches) away from the marked CP.

    Distance between CG and CP: _____

    Static Stability Margin: _____

204. Verify that Thrust-to-Weight Ratio at ignition with flight motor is GREATER THAN 5:1

205. Fill out Flight Card.

206. Copy flight info to log.

    - Motor:_____
    - Final Mass:_____
    - Expected Max Velocity:_____
    - Expected Altitude:_____
    - Thrust-to-Weight:_____

207. Red Team Sign Procedure to Confirm Rocket is Ready for Flight

Verification Signatures:

_____ _____

Red Team Member **Safety Officer**

_____

Red Team Member

PAD CHECKLIST

(TO BE SUPERVISED BY NAR MENTOR/FIELD RSO)

PPEs are REQUIRED to be worn by ALL team members around rocket

208. Take team photo with rocket
209. GPS Tracker powered on
210. Verify GPS lock with ground station
211. Take rocket, igniter, flight card, and keys to RSO
212. Verify Launch Control System is safed
213. Set Raven powered on
214. Verify audible tone from Raven
215. Place the rocket on the launch rail
216. Raise rail to desired launch position

    When applying 5° launch angle, do not aim launch rail at surrounding structure, trees, or power lines

217. Measure and record launch angle

    Angle: _____

218. ALL NON-ESSENTIAL PERSONNEL MOVE AWAY FROM PAD

219. Turn on payload deployment electronics\
220. Verify 1 Hz beep
221. Turn on Primary Stratologger power switches
222. Listen for Stratologger startup sequence
223. Check continuity: 3 beeps every 0.8 seconds
    - If unsuccessful continuity check
        - Turn off Stratologger
        - Identify problem to RSO
        - Lower launch rail
        - Remove rocket
        - Transport back to work area to debug problem
    - If continuity check successful
        - Turn off Stratologger and continue procedure
224. Turn on Backup Stratologger power switches
225. Listen for Stratologger startup sequence

226. Check continuity: 3 beeps every 0.8 seconds
    - If unsuccessful continuity check
        - Turn off Stratologger
        - Identify problem to RSO
        - Lower launch rail
        - Remove rocket
        - Transport back to work area to debug problem
    - If continuity check successful
        - Turn Primary Stratologger on and continue procedure
227. Communicate with Ground Station Team to verify GPS Tracker connection
    - If consistent GPS lock is not achieved
        - Turn off Stratologgers
        - Identify problem to RSO
        - Lower launch rail
        - Remove rocket
        - Transport back to work area to replace tracker system with backup

TEAM MENTOR COMPLETES SUBSEQUENT STEPS

228. Ensure ignitor is at proper length and is knotted/capped
229. Ensure ignitor is attached to control leads
230. Ensure igniter is in place
231. **ALL PERSONNEL MOVE AWAY FROM ALL CONNECTED PADS**
232. Confirm Continuity Check on Launch Control System
233. Arm Launch Control System

Verification Signatures:

Red Team Member **Safety Officer**

Red Team Member

POST-FLIGHT CHECKLIST

BEFORE WALKING THROUGH WOODED AREAS, OBSERVE VEGETATION

234. Take pictures before rocket is disturbed

*If the rocket is in a tree (above where a team member can reach it from the ground) or power line, **DO NOT** attempt to retrieve the rocket without assistance. **DO NOT** attempt to retrieve the rocket from powerlines.*

235. Record maximum altitude:

Maximum Altitude (Primary Stratologger): _____

Maximum Altitude (Secondary Stratologger): _____

236. Condition of Vehicle

Notes:

Verification Signatures:

Red Team Member	**Safety Officer**
Red Team Member	

FINAL CHECKLIST

237. Verify all deployment controllers are OFF
238. Condition of Shock Cord (Main and Drogue)

239. Condition of motor retention system

240. Weigh rocket:

Final weight: _____

241. Repack ALL tools, materials, and equipment for transportation
242. Dispose of all garbage in trash bag

Inspect ground for: Zip-ties, shear pins, tape, etc.

Verification Signatures:

Red Team Member **Safety Officer**

Red Team Member

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		NAR High Powered Safety Code

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%

Risk Assessment and Mitigation						
Topic: Vehicle						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Recovery Failure – Rocket Separates, parachutes don't deploy	Recovery system is packed poorly and remains in rocket.	Rocket descent is uncontrolled and dangerous.	2B	1. Successful test of recovery system before first launch. 2. The recovery system is to packed consistent with the manner used in the ground test.	1. SOP 005V1 -Black Powder demonstration – Full Scale results. 2. SOP 21 – Full Scale Launch steps 150, 169.	2E
Recovery System Failure – Rocket doesn't separate	• Ejection charges are undersized • Battery becomes disconnected during flight. • Battery voltage too low. • Stratologgers not turned on. • Switch failure. • Faulty E-Match	Rocket lodges into earth, partially or in full. Damage to rocket, people, property. Recovery ejection charges do not detonate, fail to separate rocket, shear pins don't break, parachutes do not deploy.	2D	1. Ejection charges have been tested. 2. Redundant recovery deployment systems are used. 3. Heads Up system is utilized at launch field. "Heads UP!" will be called if ballistic decent, per Range Safety Officer's direction. 4. Battery voltages are checked at launch field prior to launch.	1. SOP 005V1 -Black Powder demonstration – Full Scale results. 2. SOP 21 – Full Scale Launch steps 178, 179, 187. 3. SOP 21 – Full Scale Launch, *Test Location*. 4. SOP 21 – Full Scale Launch step 121.	2E
Recovery Failure – Excessive Main Deployment Loading	Rocket is moving too fast at main deployment.	Structural Failure. Rocket body collapse resulting in uncontrolled or unstable flight.	1D	1. Redundant recovery systems. 2. Redundant recovery deployment systems.	1. SOP 21 – Full Scale Launch steps 121. 2. SOP 21- Full Scale Launch steps 178, 179, 187.	1E
Failure to Launch	• Faulty igniter. • Faulty launch circuit. • Launch circuit not turned on.	Uncertainty in vehicle condition. Possible danger in recovering vehicle.	2C	1. Inspect components in contact with motor and handle them carefully before and after launch. 2. Continuity check on launch circuit.	1. SOP 21 – Full Scale Launch steps 194-196. 2. Confirm with RSO for continuity check.	2E
Recovery System Failure - Premature Ejection	Altimeter malfunction or ejection charge malfunction.	Rocket descent is uncontrolled and dangerous.	2D	1. Successful test of recovery system and altimeter before first launch.	1. Sub-scale launch results.	2E
Recovery System Failure – Harness Failure	Shock cord breaks. Zipper through the body tube. Harness cuts on the lip of the body tube. Parachute damaged by ejection charge.	Rocket falls in an uncontrolled manner. Damage to rocket, people, property. Recovery ejection charges do not detonate, fail to separate rocket, parachutes do not deploy.	2C	1. Parachute is packed consistently with the manner used in ejection testing. 2. Duct tape is used as reinforcement on shock cord at body tube lip. 3. Inspection of shock cord before and after flight.	1. SOP 21 – Full Scale Launch steps 150, 169. 2. SOP 21 – Full Scale Launch steps 144, 163. 3. SOP 21 – Full Scale Launch step 140, 159, 238.	2E
Recovery System Failure – Main Parachute Deploys at Apogee	Altimeter malfunction or wired improperly, faulty shear pins or not enough shear pins.	Rocket drifts beyond recoverable area or into residential area.	3B	1. Drop demonstration using expected kinetic energy to determine adequate number of shear pins. 2. Only new, unused shear pins are used.	1. SOP 17 – Kinetic Energy Drop Demonstration results. 2. SOP 21 – Full Scale Launch steps 185, 193.	3D

Risk Assessment and Mitigation						
Topic: Propulsion						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Unloaded Motor Fire	Electrostatic discharge, interference from other vehicles, heat sources.	Fire or explosion.	1D	1. Motors are handled exclusively by the Team Motor. 2. Motors are stored in locked a protective bunker. 3. Motors taken to launch field are transported in the Day Box.	1. The Safety Officer confirms transportation plans with the Team Mentor. 2. Faculty Advisor has access to locked protective case. 3. SOP 21 – Full Scale Launch steps 21. 4. SOP 21 – Full Scale Launch steps 194-196.	1E
Motor Dislodges from Proper Position	Structural failure of thrust plate, retention rings, centering rings.	Motor may eject from the rocket body. Motor thrusting up through body. Unstable flight.	2C	1. Robust motor retention. 2. Thrust plate analysis.	1. Flight testing and inspection of motor tube following test, SOP 21 – Full Scale Flight step 196. 2. Team Mentor will handle motor, SOP 21 – Full Scale Flight steps 194-196. 3. FEA results, Component Description Sheets.	2E
Moisture Content in Motor	Improper handling of motor. Insufficient weather conditions.	Motor corrosion and failure to ignite.	2C	1. Proper handling, storage, and protection of motor from moist environments. 2. Motors are only handled by the Team Mentor. 3. Motors taken to launch field are transported in the Day Box.	1. Faculty Advisor has access to locked protective case. 2. SOP 21 – Full Scale Flight step 21. 3. SOP 21 – Full Scale Flight steps 194-196.	2E
Catastrophe At Take Off (CATO)	Defective motor or motor case, unsecured motor.	Likely loss of vehicle, fire.	1D	1. Motors are only purchased from licensed vendors. 2. Motors are only handled by the Team Mentor.	1. Project Manager has submitted motor order requests as necessary. 2. SOP 21 – Full Scale Flight steps 194-196.	1E

Risk Assessment and Mitigation						
Topic: Flight						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Weather Cocking	Incorrect exit velocity or static margin.	Rocket flies off track, beyond launch field perimeter. Forces on the rocket may result in insufficient altitude.	1C	1. Simulated flight with flight software, rocket has been designed so CG/CP are in stable locations and proper exit velocity. 2. Confirm CG with loaded rocket and static margin.	1. Measure the stability margin and calculate the thrust to weight ratio based on measured weight of the rocket and accepted thrust data of motor. 2. SOP 21 – Full Scale Launch steps 199-203.	1E
Unstable Flight	Weather cocking, excessive fin flutter, or structural failure.	Unpredictable flight path or landing area. Potential to destroy the rocket.	1C	1. Simulated flight with flight software. 2. Tested rocket design with subscale flight.	1. Analyzed results. 2. Sub-scale test results.	1E
Insufficient Altitude	Insufficient thrust to weight ratio.	Rocket does not meet minimum altitude requirement.	3C	1. Simulated flight with flight software. use 2. Sub-scale launch to determine motor choice. 3. Maintain rocket in proper weight margin.	1. Analyzed software results. 2. Altimeter data from sub-scale launch. 3. SOP 21 – Full Scale Launch 201, 203.	3E
Excessive Altitude	Excessive thrust to weight ratio.	Rocket exceeds maximum altitude requirement.	3C	1. Simulated flight with flight software. 2. Sub-scale launch to determine motor choice. 3. Maintain rocket in proper weight margin.	1. Analyzed software results. 2. Altimeter data from sub-scale launch. 3. SOP 21 – Full Scale Launch 201, 203.	3E
Low Exit Velocity	High friction coefficient between rail and rail buttons, motor impulse not high enough for vehicle.	Apogee decreases, and flight becomes unstable and unpredictable.	2D	1. Members have selected motor sufficient for exit velocity and inspected vehicle components in contact with rail. 2. Rocket has at least a 5:1 thrust to weight ratio.	1. Simulation results from programs used to properly predict motor results based off vehicle weight. Average thrust is 1420 N. 2. SOP 21 – Full Scale Launch steps 201, 204.	2E
Low descent Velocity	Oversized parachute.	Vehicle flies outside of the required boundary, vehicle not recoverable.	3C	1. Simulations have been performed for recovery. 2. Calculations have been tested.	1. Simulation results. 2. Subscale flight tests.	3E
Inaccurate Calculation or Simulation	Incorrect mass of components or motor thrust resulting in wrong simulation in Openrocket.	Results are not what was expected. Unpredictable flight.	2C	1. Individual members have assigned materials to their respective parts. 2. Components and assembled rocket are weighed. 3. Rerun simulations with manufactured weights prior to launch.	1. Component Description Sheets. 2. Leads will be in charge of ensuring weight and thrust calculations to ensure predictable flight. 3. SOP 21 – Full Scale Flight step 201.	2E
High internal Pressure	High pressure differential causes rocket to separate.	Uncontrolled or unstable flight.	2D	1. Simulations have been made on all firing systems. 2. Designs have been tested.	1. Simulation results. 2. Subscale flight tests.	2E

Risk Assessment and Mitigation						
Topic: Flight						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Avionics failure	Improper charging of batteries.	Sensors and other components in avionics bay will cease to work. Flight unmanageable and not recordable.	3C	1. New batteries are used for every flight. 2. Battery voltages are checked before installation. 3. Extra batteries will be packed.	1. SOP 21 – Full Scale Flight step 21. 2. SOP 21 – Full Scale Flight steps 23, 30, 34, 121. 3. SOP 21 – Full Scale Flight step 21.	3E
High internal Pressure	Improper design for ejection methods and firing of motor.	High vacuum will cause the rocket body to collapse resulting in uncontrolled or unstable flight.	2B	1. Simulations have been made on all firing systems. 2. Designs have been tested.	1. Simulation results. 2. Subscale flight tests.	2E
Payload Deployment During Flight	Payload retention fails during flight or descent.	Uncontrolled descent of mass. Endangerment to personnel and property.	3C	1. Fail-safe retention system.	1. Vehicle Demonstration Flight test results.	3D

Risk Assessment and Mitigation						
Topic: Payload						
Risk	**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 failure of mission	2D	1. Robust battery retention has been designed, 2. Batteries are ensured to be fully charged. 3. Properly designed power system distributes power effectively.	1. SOP 23 – UAV Hover Demonstration step 21 2. SOP 23 – UAV Hover Demonstration step 21 3. SOP 23 – UAV Hover Demonstration step 21	2E
Data collection failure	Software or hardware failure due to flight loads causing wire disconnections and damage to electrical components.	Loss of data, potential failure of mission due to inability to fly	2C	1. Analysis of the system under flight loads has proven the UAV will withstand said loads. 2. Payload functionality has been successfully demonstrated prior to launch.	1. Analysis results. 2. SOP 23 – UAV Hover Demonstration 3. SOP 24 – UAV Flight Range Demonstration	2E
Signal Loss - Telemetry	Power loss to receiver/transceiver, exceeds range limits of communication system, loss of line of sight	Loss on data, loss of UAV control resulting in mission failure	2C	1. Communication system is designed and analyzed to ensure range stays within limit. 2. An autonomous return to latest GPS waypoint upon signal loss is implemented. 3. UAV has been tethered during test flights.	1. SOP 24 – UAV Flight Range Demonstration results. 2. SOP 24 – UAV Flight Range Demonstration results. 3. SOP 23 – UAV Hover Demonstration steps 7, 13-15	2E
Signal Loss - Video	Power loss to receiver/transceiver, exceeds range limits of communication system, loss of line of sight	Loss on data, loss of UAV situational awareness resulting in mission failure	2C	1. Communication system is designed and analyzed to ensure range stays within limit. 2. An autonomous return to latest GPS waypoint upon signal loss is implemented.	1. SOP 24 – UAV Flight Range Demonstration results. 2. SOP 24 – UAV Flight Range Demonstration results.	2E
Payload fails to deploy	Passive retention system fails due to flight loads, damage to deployment sheath causes deployment failure, E-match failure, insufficient black powder charge size	UAV fails to exit rocket body thereby failing mission	2C	1. The deployment system functionality is to be successfully demonstrated prior to payload demonstration launch.	1. SOP 22 – UAV Deployment System Black Powder Test	2E
Payload fails to fly	Propulsion or electrical system failure due to flight or deployment loads, UAV retention pins fail due to flight or deployment loads	UAV cannot achieve flight and thereby fails mission	2D	1. A successful payload flight is prior to the payload demonstration launch.	1. SOP 24 – UAV Flight Range Demonstration	2E
Beacon deployment system failure	Beacon retention system fails due to flight or deployment loads, signal loss	Beacon fails to deploy, beacon deploys in wrong location	3C	1. The signal range is tested in order to remain within viable range. 2. A robust beacon retention system was designed and implemented.	1. SOP 24 – UAV Flight Range Demonstration	3E

Risk Assessment and Mitigation						
Topic: Payload						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Cuts	Spinning propellers come in contact with personnel	Personnel injury.	3B	1. Barricades were placed around the UAV during testing. 2. Gloves are worn when handling UAV once batteries have been connected. 3. Only trained Red Team members have conducted test procedures.	1. SOP 23 – UAV Hover Demonstration step 8 2. SOP 23 – UAV Hover Demonstration steps 19, 39 3. SOP 21 – Full Scale Launch steps 104 4. SOP 21 – Full Scale Launch Section *Authorized Red Team Members*.	3E

Risk Assessment and Mitigation						
Topic: LiPo Batteries						
Risk	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
LiPo battery explosion	Overcharging of battery, over discharging of batteries, using hot batteries, improper storage.	Fire, release of toxic vapors	2D	1. Batteries are charged in an approved LiPo charging bag. 2. Batteries are recharged once depleted.	1. Safety Briefing 7 2. Appendix F	3D
LiPo Battery swelling, bursting	Overcharging of battery, over discharging of batteries, using hot batteries, improper storage.	Fire, release of toxic vapors	2D	1. Batteries are charged in an approved LiPo charging bag. 2. Batteries are recharged once depleted.	1. Safety Briefing 7 2. Appendix F	3D
Fire	LiPo battery explosion	Burns, damage to facilities or personnel.	3C	1. Test operators wear proper PPE. 2. Test operators followed SOP guidelines by staying safe distance away from system during test. 3. Fire extinguisher has been available in test area.	1. SOP 23 – UAV Hover Demonstration *Personal Protection Equipment (PPE)* 2. SOP 23 – UAV Hover Demonstration step 25 3. SOP 23 – UAV Hover Demonstration step 2	3E
Inhalation of toxic vapors	LiPo battery explosion, releasing of dangerous contents	Respiratory irritation	3D	1. Batteries are charged in approved LiPo charging bag. 2. Area is vacated until fumes dissipated.	1. Safety Briefing 7 2. Appendix F	4D

Hazard Assessment and Mitigation						
Environmental Hazards on System						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Shorted Circuit	Precipitation	UAV does not operate	2C	1. Remaining aware of weather conditions. 2. Do not launch in wet conditions.	1. Mandatory pre-trip team meeting. 2. SOP 25 – UAV Field Deployment and Flight *Test Location*.	2E
Moisture in Motor	High humidity, precipitation	Motor corrosion and failure to ignite	2D	1. Proper handling and storage of motor. 2. Motors will only be handled by the Team Mentor. 3. Motor installed at the end of assembly procedures. 4. Additional Launch Day motor purchased in advance.	1. Faculty Advisor has access to locked Day Box. 2. SOP 21 – Full Scale Flight steps 194-196 3. SOP 21 – Full Scale Flight steps 194-196 4. Program Manager receipts purchase requests.	2E
Black Powder Fails to Detonate	Moisture in Black Powder	Recovery deployment failure	1D	1. Black powder charges are in sealed containers. 2. Team Mentor or PRC faculty handle black powder.	1. SOP 21 – Full Scale Flight 13,14 2. Safety Briefing 2 3. SOP 21 – Full Scale Flight *Preparation of Black Powder Charges*	1E
Drift of Vehicle Beyond Recovery Zone	High winds	Vehicle lands on roads, private property, spectator area	3C	1. Rocket is not launched in winds over 20 mph.	1. SOP 21 – Full Scale Flight *Test Location*.	3D
Uncontrolled UAV Flight	High winds	Collision with spectators, miss Future Excursion Area	2C	1. UAV is not flown in winds greater than 20 mph.	1. SOP 25 – UAV Field Deployment and Flight *Test Section*.	2D
Launch Rail Positioned at Improper Angle	Uneven ground around launch rail	Rocket angled towards spectators, launched at greater angle than intended	3D	1. Launch only at approved launch site. 2. Rail angle is checked prior to arming system.	1. SOP 21 – Full Scale Launch *Test Location*. 2. SOP 21 – Full Scale Launch step 217.	3E
Impaired Launch Preparation Procedures	Winds during assembly at launch site	Low mass items (shear pins, screws, paper) blown away, increased assembly time	3D	1. Tarp and clamps are brought to be hung along awning side as a windbreak if necessary. 2. Shear pins and screws are packed in closeable containers.	1. SOP 21 – Full Scale Launch step 21.	3E
Rocket Lands in Tree	High winds, launch field dimensions overlap forested area	Damage to tree, damage to rocket, payload cannot be deployed, impaired recovery	2C	1. Rocket is not launched in winds over 20 mph. 2. Procedure for removing rocket from tree is to be followed should it be necessary. 3. Launch rail angled into wind.	1. SOP 21 – Full Scale Flight *Test Location*. 2. SOP 21 – Full Scale Launch step 236. 3. SOP 21 – Full Scale Launch step 216.	2D

Hazard Assessment and Mitigation						
Environmental Hazards on System						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Violation of Launch Preparation Procedures	Unnecessary personnel around assembly	Procedure steps skipped, completed steps are undone	2D	1. Observers in proximity to the rocket are allowed at the discretion of the Red Team. 2. Only Red Team members are permitted to operate launch procedures.	1. SOP 21 – Full Scale Launch *Observer Policy*. 2. SOP 21 – Full Scale Launch *Roles and Responsibilities*. 3. Safety Briefing 4, 6.	2E
Rocket Lands on Power Lines	High winds, launch field dimensions overlap power transmission lines	Unsuccessful recovery, payload cannot be deployed, personnel injury	2C	1. Rocket is not launched in winds over 20 mph. 2. Procedure for removing rocket is to be followed should it be necessary. 3. Launch rail angled into wind.	1. SOP 21 – Full Scale Flight *Test Location*. 2. SOP 21 – Full Scale Launch STEP. 3. SOP 21 – Full Scale Launch step 216.	2E
Rocket Lands on Private Property	High winds, launch field dimensions overlap private property	Damage to property, personnel injury, loss of launch site privileges	2C	1. Rocket is not launched in winds over 20 mph. 2. Follow Range Safety Officer's guidelines. 3. Launch rail angled into wind.	1. SOP 21 – Full Scale Flight *Test Location*. 2. Safety Briefing #. 3. SOP 21 – Full Scale Launch step 216. 4. The CRW Safety Pledge.	2E
Impaired Payload Deployment	Rocket lands in hole/ditch	Deployment system cannot eject payload assembly	2D	1. Redundant deployment charges are used. 2. Deployment demonstration to determine necessary charge sizes. 3. Minimize drift through rocket design. 4. Minimize drift through angling rocket into wind.	1. SOP 21 – Full Scale Launch step 100. 2. SOP 25 – UAV Field Deployment and Launch steps 8, 13. 3. SOP 22 – Deployment System Black Powder Testing results. 4. Vehicle Demonstration Flight results. 5. SOP 21 – Full Scale Launch step 216.	3D
Impaired Payload Deployment	Rocket lands in muddy area	Deployment system cannot eject payload assembly	2D	1. Redundant deployment charges are used. 2. Deployment demonstration to determine necessary charge sizes. 3. Minimize drift through rocket design. 4. Minimize drift through angling rocket into wind.	1. SOP 21 – Full Scale Launch step 100. 2. SOP 25 – UAV Field Deployment and Launch steps 8, 13. 3. SOP 22 – Deployment System Black Powder Testing results. 4. Vehicle Demonstration Flight results. 5. SOP 21 – Full Scale Launch step 216.	3D

Hazard Assessment and Mitigation						
System Hazards on Environment						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Ignition of Grass around Launch Rail	Dry conditions, motor sparks	Damage to launch field, personnel injury	3C	1. Motors producing particulate matter are not used. 2. Remove dead vegetation away from launch rail. 3. Launch only at approved launch sites. 4. Follow Range Safety Officer's guidelines.	1. Aerotech L1420R motor is used. 2. SOP 21 – Full Scale Launch 217. 3. SOP 21 – Full Scale Launch *Test Location*. 4. The CRW Safety Pledge.	3D
Air Pollution	Motor exhaust	Degradation in local air quality, potential long-term effects	4A	1. Motors producing particulate matter are not used.	1. Aerotech L1420R motor is used.	4C
Air Pollution	Emissions from vehicles used for transportation	Degradation in local air quality, potential long-term effects	4A	1. Team members carpool to launch sites.	1. Mandatory pre-trip team meeting.	4C
Rocket Interferes with Local Aircraft	Rocket launches in unclear airspace	Loss of launch field privileges, damage to rocket, damage to aircraft	1D	1. Launch only at approved launch sites. 2. Follow Range Safety Officer's guidelines. 3. Visually check airspace prior to launch.	1. SOP 21 – Full Scale Flight *Test Location*. 2. The CRW Safety Pledge. 3. SOP 21 – Full Scale Flight 234.	1E
UAV Interferes with Local Aircraft	UAV flies in inappropriate class airspace	Loss of UAV FAA registration, federal prosecution, damage to UAV, damage to aircraft	1A	1. UAV is only flown outdoors in uncontrolled airspace (Class G). 2. UAV is only flown below 400 ft. 3. UAV flight personnel knowledgeable of FAA regulations and local airspace restrictions.	1. SOP 25 – UAV Field Deployment and Flight *Test Location*. 2. Safety Briefing 9	1E
Land Pollution	Litter of items left at launch site by team members	Harm to farm equipment, harm to animals, loss of launch site privileges	4A	1. Team members are to collect and dispose of any debris from assembly.	1. SOP 21 – Full Scale Flight step 244.	4D
Unintended Ignition of Motor	Improper shipping of energetics	Damage to vehicle, personnel injury, loss of life	1C	1. Hazardous Shipping fee paying for proper shipping procedures.	1. Hazardous Materials Shipping Paper 2. Purchase receipts	1E

Hazard Assessment and Mitigation						
Personnel Hazards for Launches						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Reckless Driving	Sleep deprivation.	Personal injury, possible loss of life. Damage to vehicles or rocket parts.	1D	1. Drivers to launch sites are required to get six or more hours of sleep.	1. Drivers are released from launch preparation the night before launch.	1E
Dehydration	Significant time in the sun with lack water.	Dizziness, fainting, vomiting, possible loss of life.	1D	1. Team members are encouraged to bring personal water bottles.	1. Reminder announcements with suggested packing lists are distributed prior to launch.	1E
Sunburn	Prolonged exposure to direct sunlight.	Dizziness, fainting, skin irritation, heat exhaustion, heat stroke.	2B	1. Sunscreen is brought to launches. 2. Team members are recommended to wear covering clothing.	1. The Safety Officer is responsible for ensuring sunscreen available at launch site. 2. Reminder announcements with suggested packing lists are distributed prior to launch.	2D
Heat Exhaustion/Heat Stroke	Prolonged exposure to direct sunlight.	Dizziness, fainting, dehydration, confusion, possible loss of life.	1D	1. Team members are recommended to bring personal water bottles. 2. Team members are recommended to wear covering clothing. 3. Personal care is covered in a Safety Briefing.	1. Reminder announcements with suggested packing lists will be distributed prior to launch. 2. Safety Briefing 6.	1E
Person hit by Powered Rocket	Unaware of situation and surroundings.	Concussion, burns, broken bones, blunt force trauma, possible loss of life.	1D	1. Launches are clearly announced. 2. Personnel are to be in safe zones. 3. Safety Briefings cover proper launch etiquette.	1. Follow RSO guidelines. 2. Safety Briefing 6.	1E
Person hit by Unpowered Rocket	Unaware of situation and surroundings.	Concussion, broken bones, blunt force trauma.	2C	1. Proper usage of PPEs. 2. Two people must be involved in moving the rocket.	1. SOP 21 – Full Scale Launch *Personal Protective Equipment (PPE)*. 2. SOP 21 – Full Scale Launch *Roles and Responsibilities*, *Final Checkout*.	2D
Person hit by Falling Rocket Pieces	Improper retrieval from trees or tall objects.	Concussion, broken bones, blunt force trauma.	2D	1. If can be reached from the ground, rocket will be removed from the tree by minimum necessary members, other members will stand 10 ft away.	1. Safety Briefing 6. 2. SOP 21 – Full Scale Launch step 235.	2E
Person hit by Moving Vehicle	Unaware of surroundings when retrieving rocket from roadway.	Concussion, broken bones, blunt force trauma, possible loss of life.	1D	1. Surroundings are to be checked for oncoming traffic before retrieving rocket.	1. Safety Briefing 6.	1E

Hazard Assessment and Mitigation						
Personnel Hazards for Launches						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Handling of Rocket with Loaded Energetics	Rocket is loaded with energetics at prep area and hand carried to launch pad.	Concussion, broken bones, blunt force trauma.	2D	1. Maintaining situational awareness. 2. Aim rocket away from people.	1. SOP 21 – Full Scale Launch *Roles and Responsibilities*. 2. SOP 21 – Full Scale Launch *Final Checkout*.	2E
Burns	Hot rocket or hot motor case.	Skin damage, blisters, disfiguration.	2C	1. Wait until rocket and motor case have cooled before handling.	1. Safety Briefing 6. 2. Follow all RSO guidelines.	2D
Delayed Recovery Charge Detonation	Malfunctioning Stratologger.	Burns, eye injury.	2D	1. Tested Stratologgers 2. Use redundant Stratologger system. 3. Proper usage of PPEs. 4. Perform visual inspection of rocket before approaching.	1. Stratologger test results. 2. SOP 21 – Full Scale Launch steps 130, 222, 225. 3. SOP 21 – Full Scale Launch *Personal Protection Equipment (PPE)*. 4. SOP 21 – Full Scale Launch step 236.	2E
Retrieval of Rocket from Wooded Areas	Rocket drifting on descent into wooded area near launch field	Personal injury: scratches, cuts, contact with poison ivy/poison oak, bug bites/stings,	3C	1. Angle launch rail into wind to prevent excessive drift of rocket.	1. Wind check at launch site. 2. SOP 21 – Full Scale Launch step 218.	3D
Poison Ivy/Poison Oak	Walking through woods/fields to retrieve rocket after landing.	Skin irritation, allergic reaction, rash, swelling, blisters.	3C	1. Observe surrounding vegetation. 2. Carry skin ointment.	1. SOP 21 – Full Scale Launch *Post-Flight Checklist*. 2. Safety Briefing 6.	3D
Bug Stings/Bites	Unaware of surroundings, lack of insect repellent	Skin irritation, allergic reaction, blisters	3C	1. Observe surroundings 2. Carry insect repellent 3. Carry skin ointment	1. SOP 21 – Full Scale Launch *Post-Flight Checklist*. 2. Safety Briefing 6.	3D

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	1. Red Team will be trained on fire procedures. 2. Flammable material will be kept away from test area. 3. Test operators will wear proper PPE. 4. E-matches are placed in centrifuge cups to contain debris.	1. Safety Briefing 1. 2. SOP 21 – Full Scale Launch step 3. 3. SOP 21 – Full Scale Launch *Personal Protection Equipment (PPE)*. 4. SOP 21 – Full Scale Launch steps 13, 14.	3E
Burns	Fire from ignition of E-match, inadvertent ignition of E-Match.	Personnel injury	3C	1. Test operators will wear proper PPE. 2. E-Matches to be handled only by team mentor or PRC faculty member	3. SOP 21 – Full Scale Launch *Personal Protection Equipment (PPE)*. 4. SOP 21 – Full Scale Launch *Preparation of Black Powder Charges*	3E

Hazard Assessment and Mitigation						
Chemical Handling: Black Powder, Loose						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Unintentional Detonation	Friction, heat, outside sources of energy, improperly handled.	Fire or explosion. Immediate physical danger potentially resulting in severe injury or death. Minor damage to facilities.	1B	1. Safe handing by trained personnel. 2. Correct PPE including impervious rubber gloves and non-static producing clothing.	1. Only Red Team members are allowed to conduct test. 2. SOP 005-V1- Black Powder Demonstration – Full Scale, SOP 21 – Full Scale Flight *Personal Protection Equipment (PPE)*. 3. MSDS is included in Appendix E of SOP 005-V1- Black Powder Demonstration – Full Scale, SOP 21 – Full Scale Flight.	1D
Damage respiratory system.	Chronic exposure without PPE. Inhalation or Skin Contact with Powder.	Severe irritation. Choking hazard, permanent respiratory damage.	2C	1. Use in well ventilated areas.	1. SOP 005-V1- Black Powder Demonstration – Full Scale, SOP 21 – Full Scale Flight *Test Location*. 2. MSDS is included in Appendix E of SOP.	2E
Damage to skin	Chronic exposure without PPE. Inhalation or Skin Contact with Powder.	Severe irritation.	2C	1. Ensure safe work practices. 2. Correct PPE and covering clothing, long pants.	1. Safety Briefing 6. 2. SOP 005-V1- Black Powder Demonstration – Full Scale, SOP 21 – Full Scale Flight *Personal Protection Equipment (PPE)*. 3. MSDS is included in Appendix E of SOP 005-V1- Black Powder Demonstration – Full Scale, SOP 21 – Full Scale Flight.	2E
Uncontrolled Ignition of Black Powder	Ignition due to ESD	• Damage to facility • Injury from debris • Hardware Damage • Fire	3D	1. Wires are shorted together to prevent buildup. 2. Access to test area is restricted when testing. 3. Arm key provides physical break in igniter circuit. 4. Always point rocket away from all personnel.	1. SOP 005-V1- Black Powder Demonstration – Full Scale SOP steps 19, 32, 77. 2. SOP 005-V1- Black Powder Demonstration – Full Scale steps 5, 17. 3. SOP 005-V1- Black Powder Demonstration – Full Scale steps 8, 13, 36, 43, 54, 70. 4. Setup is done in accordance with safe testing practices.	3E

Hazard Assessment and Mitigation						
Chemical Handling: Black Powder, Loose						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Uncontrolled Ignition of Black Powder	Ignition during connecting or disconnecting battery	• Damage to facility • Injury from debris • Hardware Damage • Fire	3D	1. Wires are shorted together to prevent buildup. 2. Access to test area is restricted when testing. 3. Arm key provides physical break in igniter circuit. 4. Always point rocket away from all personnel.	1. SOP 005-V1- Black Powder Demonstration – Full Scale SOP steps 19, 32, 77. 2. SOP 005-V1- Black Powder Demonstration – Full Scale steps 5, 17. 3. SOP 005-V1- Black Powder Demonstration – Full Scale steps 8, 13, 36, 43, 54, 70. 4. Setup is done in accordance with safe testing practices.	3E
Personnel exposed to live circuit	Uninsulated wires/worn insulation	Electric Shock	3C	1. Arm key provides physical break in igniter circuit. 2. Trained personnel will be making battery connections.	1. SOP 005-V1- Black Powder Demonstration – Full Scale steps 8, 13, 36, 43, 54, 70. 2. Only Test Conductor are authorized to connect the battery under the discretion of the Safety Monitor.	3D

Hazard Assessment and Mitigation						
Chemical Handling: Alcohol, Ethanol						
Hazard	**Cause**	**Effect**	**Pre-RAC**	**Mitigation**	**Verification**	**Post-RAC**
Contact with Eyes	Improper handling.	Severe irritation.	3D	1. Proper PPE including safety glasses. 2. Chemical must be used in close proximity to an eyewash station.	1. Safety Briefing 6.	3E
Skin Exposure	Improper handling and/or lack of proper PPE.	Moderate irritation.	3C	1. Proper PPE including gloves and protective clothing.	1. Safety Briefing 6.	3E
Inhalation	Chronic exposure without PPE and/or insufficient ventilation.	Irritation.	3C	1. Use in well ventilated area.	1. Safety Briefing 6.	3E
Unintentional Combustion	Presence of open flames, sparks, heat, or oxidizing materials.	Fire, damage to personnel, hardware, and facilities.	1B	1. Safe workplace practices. 2. Avoiding flame.	1. Safety Briefing 6.	1E

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 lest 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.

Robert A Frederick

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.

Emergency Phone Numbers	
Police	911 (256) 824-6911 (6911 from campus phone)
Fire Department	
Hazardous Materials Incident	
Utility Failure	
PRC Contacts	
Tony Hall	Office : (256) 824-2887
David Lineberry	Office : (256) 824-2888
Robert Frederick	Office : (256) 824-7200
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
Other Emergency Numbers of Interest	
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. UAHuntsville Police (Non-Emergency)
(256) 824-6596
6596 (from campus phone)

APPENDIX E: MATERIAL SAFETY DATA SHEETS

AeroTech Division, RCS Rocket Motor Components, Inc.
Material Safety Data Sheet & Emergency Response Information

Prepared in accordance with 29 CFR § 1910.1200 (g)

Section 1. Product Identification

Model rocket motor, high power rocket motor, hobby rocket motor, composite rocket motor, rocket motor kit, rocket motor reloading kit, containing varying amounts of solid propellant with the trade names White Lightning™, Blue Thunder™, Black Jack™, Black Max™, Redline™, Warp-9™, Mojave Green™, Metalstorm™, Metalstorm DM™ or Propellant X™. These products contain varying percentages of Ammonium Perchlorate, Strontium and/or Barium Nitrate dispersed in synthetic rubber with lesser amounts of proprietary ingredients such as burn rate modifiers and metal fuels. Rocket motor ejection charges contain black powder.

Section 2. Physical Characteristics

Black plastic cylinders or bags with various colored parts, little or no Odor

Section 3. Physical Hazards

Rocket motors and reload kits are flammable; rocket motors may become propulsive in a fire. All propellants give off varying amounts of Hydrogen Chloride and Carbon Monoxide gas when burned, Mojave Green propellant also produces Barium Chloride.

Section 4. Health Hazards

Propellant is an irritant in the case of skin and eye contact, may be extremely hazardous in the case of ingestion, and may be toxic to kidneys, lungs and the nervous system. Symptoms include respiratory irritation, skin irritation, muscle tightness, vomiting, diarrhea, abdominal pain, muscular tremors, weakness, labored breathing, irregular heartbeat, and convulsions. Inhalation of large amounts of combustion products may produce similar but lesser symptoms as ingestion.

Section 5. Primary Routes of Entry

Skin contact, ingestion, and inhalation.

Section 6. Permitted Exposure Limits

None established for manufactured product.

Section 7. Carcinogenic Potential

None known.

Section 8. Precautions for Safe Handling

Disposable rubber gloves are recommended for handling Mojave Green propellant. Keep away from flames and other sources of heat. Do not smoke within 25 feet of product. Do not ingest. Do not breathe exhaust fumes. Keep in original packaging until ready for use.

Section 9. Control Measures

See section 8.

Section 10. Emergency & First Aid Procedures

If ingested, induce vomiting and call a physician. If combustion products are inhaled, move to fresh air and call a physician if ill effects are noted. In the case of skin contact, wash area immediately and contact a physician if severe skin rash or irritation develops. For mild burns use a first aid burn ointment. For severe burns immerse the burned area in cold water at once and see a physician immediately.

Section 11. Date of Preparation or Revision

March 22, 2012

Section 12. Contact Information

AeroTech Division, RCS Rocket Motor Components, Inc.
2113 W. 850 N. St.
Cedar City, UT 84721
(435) 865-7100 (Ph)
(435) 865-7120 (Fax)
Email: customerservice@aerotech-rocketry.com
Web: http://www.aerotech-rocketry.com

Emergency Response: Infotrac (352) 323-3500

Goex Powder, Inc.

Material Safety Data Sheet

MSDS-BP (Potassium Nitrate)

Revised 3/17/09

PRODUCT INFORMATION	
Product Name	Black Powder
Trade Names and Synonyms	N/A
Manufacturer/Distributor	GOEX Powder, Inc.(DOYLINE, LA) & various international sources
Transportation Emergency	800-255-3924 (24 hrs – CHEM TEL)

PREVENTION OF ACCIDENTS IN THE USE OF EXPLOSIVES

The prevention of accidents in the use of explosives is a result of careful planning and observance of the best known practices. The explosives user must remember that he is dealing with a powerful force and that various devices and methods have been developed to assist him in directing this force. He should realize that this force, if misdirected, may either kill or injure both him and his fellow workers.

WARNING

All explosives are dangerous and must be carefully transported, handled, stored, and used following proper safety procedures either by or under the direction of competent, experienced persons in accordance with all applicable federal, state and local laws, regulations, or ordinances. ALWAYS lock up explosive materials and keep away from children and unauthorized persons. If you have any questions or doubts as to how to use any explosive product, DO NOT USE IT before consulting with your supervisor, or the manufacturer, if you do not have a supervisor. If your supervisor has any questions or doubts, he should consult the manufacturer before use.

HAZARDOUS COMPONENTS				
Material or Components	%	CAS NO.	TLV	PEL
Potassium nitrate	70-76	007757-79-1	NE	NE
Charcoal	8-18	N/A	NE	NE
Sulfur	9-20	007704-34-9	NE	NE
Graphite[1]	Trace	007782-42-5	15 mppct (TWA)	2.5 mg/m³
N/A = Not assigned NE = Not established				

[1] Not contained in all grades of black powder.

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P.O. Box 659, Doyline, LA 71023-0659, (318) 382-0300
www.goexpowder.com

PHYSICAL DATA	
Boiling Point	N/A
Vapor Pressure	N/A
Vapor Density	N/A
Solubility in Water	Good
Specific Gravity	1.70 – 1.82 (mercury method) 1.92 – 2.08 (pycnometer)
PH	6.0 – 8.0
Evaporation Rate	N/A
Appearance and Odor	Black granular powder. No odor detectable.

HAZARDOUS REACTIVITY	
Instability	Keep away from heat, sparks, and open flames. Avoid impact, friction and static electricity.
Incompatibility	When dry, black powder is compatible with most metals; however, it is hygroscopic and when wet, attacks all common metals except stainless steel. Black powder must be tested for compatibility with any material not specified in the production/procurement package with which they may come in contact. Materials include other explosives, solvents, adhesives, metals, plastics, paints, cleaning compounds, floor and table coverings, packing materials, and other similar materials, situations, and equipment.
Hazardous decomposition	Detonation produces hazardous overpressures and fragments (if confined). Gases produced may be toxic if exposed in areas with inadequate ventilation.
Polymerization	Polymerization will not occur.

FIRE AND EXPLOSION DATA	
Flashpoint	Not applicable
Auto Ignition Temperature	Approx. Range: 392°F-867°F / 200°C-464°C
Explosive temperature (5 sec)	Ignites @ approx. 427°C (801°F)
Extinguishing media	Water
Special fire fighting procedures	ALL EXPLOSIVES: DO NOT FIGHT EXPLOSIVES FIRES. Try to keep fire from reaching explosives. Isolate area. Guard against intruders. Division 1.1 Explosives (heavily encased): Evacuate the area for 5,000 feet (approximately 1 mile) if explosives are heavily encased. Division 1.1 Explosives (not heavily encased): Evacuate the area for 2,500 feet (approximately ½ mile) if explosives are not heavily encased. Division 1.1 Explosives (all): Consult U.S. DOT Emergency Response Guide 112 for further details.

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Unusual fire and explosion hazards	Black powder is a deflagrating explosive. It is very sensitive to flame and spark and can also be ignited by friction and impact. When ignited unconfined, it burns with explosive violence and will explode if ignited under even slight confinement.

HEALTH HAZARDS	
General	Black powder is a Division 1.1 Explosive, and detonation may cause severe physical injury, including death. All explosives are dangerous and must be handled carefully and used following approved safety procedures under the direction of competent, experienced persons in accordance with all applicable federal, state and local laws, regulation and ordinances.
Carcinogenicity	None of the components of Black Powder are listed as a carcinogen by NTP, IARC, or OSHA.

FIRST AID	
Inhalation	Not a likely route of exposure. If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably by mouth-to-mouth. If breathing is difficult, give oxygen. Seek prompt medical attention. Avoid when possible.
Eye and skin contact	Not a likely route of exposure. Flush eyes with water. Wash skin with soap and water.
Ingestion	Not a likely route of exposure. If ingested, dilute by giving two glasses of water and induce vomiting. Avoid when possible.
Injury from detonation	Seek prompt medical attention.

SPILL OR LEAK PROCEDURES	
Spill/leak response	Use appropriate personal protective equipment. Isolate area and remove sources of friction, impact, heat, low level electrical current, electrostatic or RF energy. Only competent, experienced persons should be involved in clean up procedures. Carefully pick up spills with non-sparking and non-static producing tools.
Waste disposal	Desensitize by diluting in water. Open train burning, by qualified personnel, may be used for disposal of small unconfined quantities. Dispose of in compliance with Federal Regulations under the authority of the Resource Conservation and Recovery Act (40 CFR Parts 260-271).

SPECIAL PROTECTION INFORMATION	
Ventilation	Use only with adequate ventilation. (If required)
Respiratory	None
Eye	None
Gloves	Impervious rubber gloves. (If required)
Other	Metal-free and/non-static producing clothes

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SPECIAL PRECAUTIONS
• Keep away from friction, impact, and heat and open flame. Do not consume food, drink, or tobacco in areas where they may become contaminated with these materials. • Contaminated equipment must be thoroughly water cleaned before attempting repairs. • Use only non-spark producing tools. • No smoking.

STORAGE CONDITIONS
Store in a cool, dry place in accordance with the requirements of Subpart K, ATF: Explosives Law and Regulations (27 CFR 55.201-55.219).

SHIPPING INFORMATION		
Proper shipping name	Black Powder	
Hazard class	1.1D	
UN Number	UN0027	
DOT Label & Placard	DOT Label	EXPLOSIVES 1.1D
	DOT Placard	EXPLOSIVES 1.1
Alternate shipping	Limited quantities of GOEX black powder (1# cans only) may be transported as "Black powder for small arms – flammable solid" pursuant to U.S. Department of Transportation 49 CFR.	

The information contained in this Material Safety Data Sheet is based upon available data and believed to be correct; however, as such has been obtained from various sources, including the manufacturer, military and independent laboratories, it is given without warranty or representation that it is complete, accurate, and can be relied upon. GOEX, Incorporated, has not attempted to conceal in any manner the deleterious aspects of the product listed herein, but makes no warranty as to such. Further, GOEX, Incorporated, cannot anticipate nor control the many situations in which the product or this information may be used; there is no guarantee that the health and safety precautions suggested will be proper under all conditions. It is the sole responsibility of each user of the product to determine and comply with the requirements of all applicable laws and regulations regarding its use. This information is given solely for the purposes of safety to persons and property. Any other use of this information is expressly prohibited.

For further information contact: GOEX Powder, Incorporated
P. O. Box 659
Doyline, LA 71023-0659
Telephone Number: (318) 382-9300
Fax Number: (318) 382-9303

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BLACK POWDER

FRICTION TEST
PA

Steel – Snaps
Fiber – Unaffected

IMPACT TEST
PA

16 Inches (10% Point)

ELECTROSTATIC DISCHARGE TEST

Bureau of Mines
0.8 Joules (Confined)
12.5 Joules Unconfined)

STABILITY

75° C International Heat Test – 0.31% Loss
Vacuum Stability – 0. 5cc @ 100° C

BRISANCE – Sand Test 8 gm.

VELOCITY

In the open, trains of black powder burn very slowly, measurable in seconds per foot. Confined, as in steel pipe, speeds of explosions have been timed at values from 560 feet per second for very coarse granulations to 2,070 feet per second for the finer granulations. Confinement and granulation will affect the values.

CHEMICAL DECOMPOSITION

Use water to dissolve the potassium nitrate. By leeching out the potassium nitrate, the residue of sulfur and charcoal is non-explosive but combustible when dry – dispose separately.

SPECIAL REQUIREMENTS:

Black Powder is very sensitive to flame and spark and can also be ignited by friction and impact. When ignited unconfined, it burns with explosive violence and will explode if ignited under even slight confinement.

When dry, it is compatible with most metals. However, it is hydroscopic and when wet, attacks all common metals except stainless steel.

CAUTION: Explosives must be tested for compatibility with any material not specified in the production/procurement package with which they may come in contact. Materials include other explosives, solvents, adhesives, metals, plastics, paints, cleaning compounds, floor and table coverings, packing materials and other similar materials, situations and equipment. Explosives include propellants and pyrotechnics.

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