

Section 1.2: Launch Field Safety

When any or all team members are at a launch field used for launching any level rocket there will be strict code of conduct followed by all members of the Auburn University Student Launch program. First and foremost all members will abide by the rules set forth by the Range Safety Officer (RSO) unless there is a regulation by Auburn University that is stricter than the rules set forth by the RSO. All members will be required to stay well past the distance required away from the launch pad when members are not either positioning the rocket on the launch pad or retrieving the rocket after the recovery sequence has completed. Team members will be required to wear the proper clothing on the day of launch including having a pair of sunglasses and/or a hat. Correct clothing will be decided by the Auburn Safety Officer and Project Manager, and an email will be sent out to all the members of the team to inform them on what will be required of them to wear on launch day. No rough-housing or wild behavior will be tolerated by the Auburn team on or around the launch field. Depending on the length of the launch period and time of year members of leadership for the Auburn team will ensure that beverages and sunscreen will be available for members of the Auburn team.

Section 1.3: Outreach Safety

When performing an outreach event the members of the Auburn University Student Launch (AUSL) team will be paired up will at least one student from the school and will assist the student in understanding the physics behind a working rocket and will assist in the fabrication of the rockets with the students. During the fabrication of the model rockets the members of AUSL will ensure that all of the students are wearing the proper protective equipment and are assembling the kits in the correct form. This will be done to ensure that all models are stable in flight and are the safest that they can be. On the days that the students will be launching their rockets the launch pads will be set up so the rockets launch away from all structures and all personnel on the launch field. A minimum observation distance will be marked off to ensure correct distance away from the launch pads. There will be a minimum of one fire extinguisher on site in case of a grass fire caused by a rocket. Also prior to launch the ground surrounding the launch site will be wet down to ensure safest launch area. After rockets have been launched the members of AUSL will retrieve them and remove the spent rocket motors before returning the models to the students.

Section 1.4: Handling and Disposal of Hazardous Materials

Any material that is used during either the fabrication process or the actual flight that can cause harm to either a human or the rocket structure is considered a hazardous material. These materials should be handled with care making sure to wear all the proper personal protective equipment including but not limited to long pants, close toe shoes, eye protection, hand protection, and respirator. Any personnel handling hazardous materials will have knowledge of the Material Safety Data Sheet booklet in the lab incase an incident occurs that requires extra action. Also if the personnel is unaware of the correct handling practices for a certain hazardous material and experienced member will be there to teach and assist when needed. Proper disposal units for the different hazardous materials are in all the labs and all members of AUSL will be informed of the correct receptacles that are to be used for disposing of certain hazardous materials.

Section 1.5: Transportation

When traveling to and from an event, always follow the states driving laws. Seatbelts must be worn by all passengers while in the car. Speed limits must be followed while on the road. The driver must maintain proper distance from other cars. The driver must have a valid driver's license and not be impaired by any form of drugs and/or alcohol. The driver must also have had adequate sleep the night before. Passengers are not allowed to impede focus of the driver.

All materials being transported must be secured and properly packaged. All dangerous chemicals and black powder must be stored in proper storage to prevent accident discharge. All fragile equipment must be stored in cushioned containers and secured in some fashion that will allow the equipment to be considered immobile.

Section 1.6: Hand tools

All hand tools must be properly handled and cared for before use. Hand tools must also be sorted and replacement parts be readily available. When working with hand tools proper attire must be worn, including long pants, closed toe shoes, upper torso protective equipment, and safety glasses. If working with fibrous material, respirators must be worn. Any area that is being worked in with hand tools should be cleared of all debris and the area must be clearly marked. After completion of work with tools, all tools must be cleaned along with the work area, and the tools must be properly stored for continued efficient use.

Section 1.7: 3-D Router Procedures

The 3-D router must first be cleared of all debris from previous use before it can be used. Router bit must be checked beforehand to ensure it will work to a standard efficiency. The design of what is being machined must be created beforehand in a CAD program. Safety glasses must be worn at all times while the router is in use. If the router is routing anything other than wood, respirators must be used to ensure dust particles do not enter mouth or lungs. Before routing can begin, the router must be set to an origin point as established by the user. Also the material must be stabilized before routing can begin. Once set, cutting may commence. A supervisor must be overlooking the 3-D router while it is in use and be ready to press the emergency stop if the router runs into a problem or is not doing the job tasked to it. Vacuuming excess dust and material is needed during operation to prevent build up. After completion area should be cleaned up and waste items properly disposed of.

Section 1.8: 3-D Printer

To use the 3-D printer the first step is to make a model using a CAD software. After a 3-D model is made using CAD software it will need to be converted to a standard tessellation language format. This is the language that the 3-D printer uses to read the model in. A user will copy the STL file to the computer that controls the 3-D printer. At this point the user can designate the size and orientation for printing. The build process is automatic. Each layer is usually about 0.1 mm thick. The process could take hours or days to complete. The machine should be checked periodically to make sure there are no errors in the model. After the 3-D printer stops the model will be removed.

Section 1.9: Airframe

Section 1.9.1: Manufacturing

With the assistance of GKN Aerospace, the team has elected to utilize the equipment at their facility in Tallasee, Alabama. Filament winding the body of the aircraft provides a unique opportunity to reduce the weight of the rocket. By utilizing unidirectional strength carbon, which is typically much thinner and much lighter than twill-weave or other woven carbon cloths, the team can significantly reduce the weight of the rocket. Normally, this presents trade-offs in tensile or compressive strength properties, as the unidirectional carbon is not as strong when not loaded axially.

However, with careful consideration of the ply orientation through combining several different ply orientations within the design, the material can be constructed to be much more versatile in its strength properties, while still maintaining the weight savings provided by unidirectional carbon. By teaming up with GKN, Project WALL-Eagle is able to gain the vast experience of their composite technicians in helping to design the ply design, as well as using their filament winding apparatus to actually construct the body tubes of the rocket. In addition, with the precision of a CNC guided machine winding the fibers, the final finished quality of the body tubes is significantly enhanced from a hand layed-up body tube. This results in a much more aerodynamic surface for air to flow around the body tube, with far less work required to refine the body tube.

Section 1.9.2: Testing

When testing is being done of the Airframe the proper personal protective equipment will be worn by all team members that are present at the time of the testing. To minimize hazards team members will be required to keep a safe distance from the part that is being tested.

Section 1.9.3: Pre-Flight

During Pre-Flight the Airframe will be inspected for Cracks in the airframe, Gaps between the airframe and other parts of the rocket and lack of epoxy. The fins of the airframe will be inspected to make sure enough epoxy was applied to ensure that the fins stay intact upon launch and landing. If there is not enough epoxy then more will be applied to the fins. After the airframe has been inspected to make sure it is launch worthy it may be move to the launch area.

Section 1.9.4: Post-Flight

During Post-Flight the same steps that were taken in Pre-Flight will be performed again. The airframe will be inspected for Cracks and gaps that were caused on impact. The fins will also be inspected to make sure they are still secure and if more epoxy is needed to keep them secure. If there are any cracks or gaps in the airframe after the launch the airframe will be returned to the lab to be inspected and to fix whatever the problem may be.

Section 1.10: AGSE

Section 1.10.1: Manufacturing

The robot arm will be assembled using the servos, aluminum brackets, screws, and control unit. Additional sections will be added to the configuration of the robot arm to allow the arm to reach farther. Normal personal protective equipment should be worn during this phase of construction. The base of the system will be made of plywood coated in carbon fiber. The plywood will be cut using a table saw and will be secured together at key locations. The boxes will be hollow to allow for storage and the electronics used in controlling the AGSE and rocket. The carbon fiber will be cut to size and attached to the outside of the plywood boxes to apply an extra level of strength and fire protection for the wood. After the boxes are finished then the frame that will connect the boxes will be constructed. The next part to be constructed will be the truss that the launch rail will rest on. The truss will be constructed of high strength carbon fiber and when working with carbon fiber you should wear eye protection, skin protection, gloves, and respiratory protection. After the truss is constructed the axle on which the truss will be rotated will be fabricated into the box structure and then the electric motor and gears will be connected to the axle. After the motor is connected all the electrical hardware including controllers for the motor and electronic ignitor will be inserted into the boxes. Once the main base system is constructed then the truss with launch rail, blast plate, electronic ignitor insertion unit, and counter weight now connected, this complete system will be joined to the axle.

Section 1.10.2: Testing

Static testing will occur first with testing all the electrical systems ensure that everything is connected and receiving the correct amount of power from the batteries. Then the whole structure will be checked over and statically tested to ensure everything is put together correctly. After the construction is up to the correct standards and is signed off by the AGSE team lead and the safety office dynamic testing can begin. Dynamic testing will consist of at first the AGSE system going through the separate motions of each system independently to ensure proper functioning. Next the different sections will be added into the order in the correct order that they will execute during a launch sequence. Then after all systems are added in and functioning properly a dummy rocket will be added into the system to ensure proper functionality. Once that testing is successful then practice launch sequences will commence.

Section 1.10.3: Pre-Flight

The different pieces of the AGSE system will be collected out of their respective transport containers and final on-site assembly will commence. All pieces will be securely fastened in the correct fashion and after assembly is complete there will be a final construction check and sign-off by both the AGSE team lead and the safety officer. Then the correct wires will be connected and a final systems check will be completed. After a successful systems check the rocket will be inserted onto the launch rail and the complete system will be ready for launch.

Section 1.10.4: Post-Flight

After the flight is completed the AGSE system will be looked over for any damage and the supplied power will be disconnected. Then the system will be broken down for transport back to home base.

Section 1.11: Recovery

Section 1.11.1: Manufacturing

During production of the recovery systems, work area must be cleared beforehand to prevent damage of any part of the rocket. Proper clothing will be worn in laboratory area. Proper clothing specifically includes long pants, closed toe shoes, and upper body protective equipment. Operations including sanding machines, hand tools, and using the drill press, sowing machine, and 3-D printer must wear extra operational clothing. Safety glasses, work gloves, and respirators must be worn when operating this equipment. Proper knowledge on how to operate the machinery and tools must be known before work may begin. If an inexperienced person is working with this equipment, an experienced worker must be supervising at all times. Safety equipment must be clearly labeled and easily accessible throughout the lab. Safety equipment includes fire extinguisher, first aid kits, eye washing station, and readily available telephone. If any of this equipment is unavailable the lab is not to be used until such equipment becomes available.

The parachutes are constructed from ripstop nylon and tubular nylon chords. The parachutes were cut from patterns and sown together with a French slip seam sewing. It is meant to keep everything on the inside of the parachute and it provides additional strength to the parachute. The rough edges are hemmed to prevent fraying. The tubular nylon chords are attached by sewing.

The ejection system being created for our rocket is a carbon dioxide based. The casing used to hold the cartridges were 3-D printed with ABS plastic in a pattern to hold 3 cartridges. The ignitors, springs, pyrodex, and cartridges were store bought. The charge cap, the lift piston, the alignment collar, and the casing cylinder were machined out of aluminum by our in house machinist. To create the system, first clean all the parts using water and paper towels from previous use. Then, insert the igniter into the hole on the bottom of the charge cap into its final place. Place one drop of epoxy to seal the ignitor into place. Once the epoxy has dried, measure 0.15 grams of pyrodex and fill the reservoir of the charge cap. Cover the pyrodex with painters tape and cut off all excess painter tape. Next, load the charge cap into the base of the casing cylinder. Load the casing cylinder with the charge cap into the charge half of the casing making sure the ignitor wires come through the holes at the base of the casing. Using a silicon based lubricant, lubricate the lift piston. Slide the lift piston into the case cylinder already inside of the casing. Use the butt end of the 12 gram CO2 cartridge to push down the lift piston to the bottom where it meets the charge cap. Place the alignment collar onto the tip of the CO2 cartridge. Repeat steps for the rest of the chambers. Moving on, place a spring into each of the chambers of the pin half of the casing. Laying both halves of the casing flat on a table, with the holes facing each other, slide the two halves of the casing together. Make sure the CO2 cartridges enter their respective holes. Holding the two halves together, screw the casing together with the casing screws. Finally, place in rocket and wire charges to the altimeter.

Section 1.11.2: Testing

Prior to testing the manufactured equipment, testing area must be cleared beforehand of debris and test area must be established.

Parachutes will be tested through scaled models placed in the 2x2 wind tunnel. The seals on the parachute will be placed through a tensile strength test. There will also be many subscale tests using parachutes created in the design of the final rocket.

The CO2 ejection system will be tested through 2 methods. The first method for testing the CO2 system is to assemble it, secure it, and activate in a designated testing area. The second method is to have the assembled recovery system in its entirety in the upper part of the rocket and test the CO2 system on the ground in a designated testing area to ensure the parachutes are deployed.

Section 1.11.3: Pre-Flight

Parachutes will be checked to make sure the chords are attached and there are no holes in the parachutes. Fireproofing material will be placed between rocket motor and the rest of the recovery system. The parachute will be placed in the rocket with the chords untangled and flight ready. The nose cone will be checked to make sure it comes off during parachute ejection.

To prepare the CO2 recovery system for flight, first clean all the parts using water and paper towels from previous use. Then, insert the igniter into the hole on the bottom of the charge cap into its final place. Place one drop of epoxy to seal the igniter into place. Once the epoxy has dried, measure 0.15 grams of pyrodex and fill the reservoir of the charge cap. Cover the pyrodex with painter's tape and cut off all excess painter tape. Next, load the charge cap into the base of the casing cylinder. Load the casing cylinder with the charge cap into the charge half of the casing making sure the ignitor wires come through the holes at the base of the casing. Using a silicon based lubricant, lubricate the lift piston. Slide the lift piston into the case cylinder already inside of the casing. Use the butt end of the 12 gram CO2 cartridge to push down the lift piston to the bottom where it meets the charge cap. Place the alignment collar onto the tip of the CO2 cartridge. Repeat steps for the rest of the chambers. Moving on, place a spring into each of the chambers of the pin half of the casing. Laying both halves of the casing flat on a table, with the holes facing each other, slide the two halves of the casing together. Make sure the CO2 cartridges enter their respective holes. Holding the two halves together, screw the casing together with the casing screws. Finally, place in rocket and wire charges to the altimeter.

Section 1.11.4: Post-Flight

After the rocket has launch, the team will look for the parachutes to deploy when scheduled. The team will go to the rocket and check the ground around the rocket to make sure the parachutes haven't caught fire. The team will also carefully make sure the carbon dioxide canisters have gone off. Once the rocket is picked up the team will search for any debris left when the rocket landed. All recovery equipment will be taken apart, repaired if needed, and cleaned for next launch.

Section 1.12: Outreach

Section 1.12.1: Manufacturing

Transport model rocket kits to outreach site. Demonstrate to students the construction of model rocket using these steps. Cover rocket mold, tape strings to parachute, secure eyelet to parachute, screw eyelet into nosecone, then loop shock chord to eyelet. Next secure tube to body, assemble engine mount, glue engine mount into rocket mold, insert parachute into top of rocket model, insert engine into mount, and then attach fins via glue. Supervise and help students create model rockets using instructions provided.

Section 1.12.2: Testing

Prior to launch supervisors will monitor construction of the model rockets and do an overall inspection to ensure proper construction. Supervisors will aid any students needing help.

Section 1.12.3: Pre-Flight

Supervisors will aid students with insertion of the rocket motor and with pre-launch final assembly and will assist mounting rockets onto launch rail on launch platform. Students will be kept a safe distance away from launch pads. Rocket launch pads will be spaced evenly apart. Countdown for model rocket launches will ensure all rocket launches will not be unanticipated.

Section 1.12.4: Post-Flight

Rockets will be recovered by the members of the Auburn University Student Launch program at which time they will remove the rocket motor and then return the rocket model to the student. All precautions will be taken to ensure the safety of all the personnel participating in this event.