Dust Resistant Tool For Lunar Obtainment of Surface Samples (DRTFLOSS)

Lunar Surface Operations - Dust Tolerant Lunar Sample Device

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I. Technical Section

A. Abstract

The proposed design for the DRTFLOSS intends to ease and improve an astronaut's capability to collect float samples from a low gravity environment. It will be lightweight at 2.73 pounds and a maneuverable length of 34.95 inches for maximum performance, composed primarily of Aluminum 6061. Specialized protective measures have been established by the design team to ensure the device's tolerance to dust and eliminate any risk of harm to astronaut or lunar environment. The DRTFLOSS will also be powered manually, as the user only requires one hand to squeeze the handle, compressing a spring within the device and causing the pivot at the bottom of the device to open. Once a sample is collected, the clamping tongs will close around the sample to prevent it from falling out of the scoop. Durability in the device will make it reusable for multiple missions, despite its repeated complete submersion in dust. Following a manufactured prototype, preliminary testing with the DRTFLOSS will ensure the successful obtainment of appropriately sized samples.

B. Design Description

1. Design

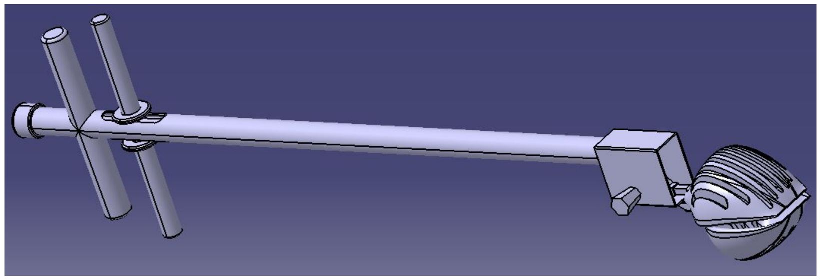

Figure 1: Complete Design Assembly.

1) *Inner Tube Sub-assembly*

The Inner tube sub-assembly is comprised of the Inner Tube, Inner Tube Adapter, Joint Linkage Arm, Lever, Linkage pins, Pin, Pin Cap, and Top Clamp. The Inner Tube is the main component that transfers the pulling energy of the astronaut's fingers to lever mechanism. This pulling motion is applied to the handle sub-assembly that connects to the inner tube opposite the lever mechanism via a threaded shaft through two drilled holes. The pulling motion of the sliding handles toward the fixed handles compresses the spring. This longitudinal motion, parallel to the main body, transfers into the lever mechanism via the lever action linkage, then causing a pivoting motion on the Lever to open the Top Clamp, which ultimately allows the astronaut to encapsulate the lunar sample.

The astronaut then releases the aforementioned pull motion which will cause the spring to decompress to its initial state, moving the Inner Tube back to its original position, lowering the Top Clamp onto the static scoop thus encapsulating the sample. Both the Top and Bottom Clamp will be made of a slotted surface to allow lunar soil that is unwanted to sift through.

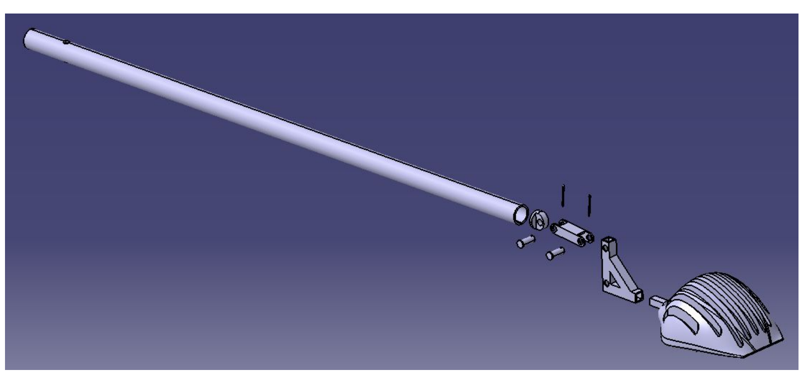

Figure 2: Inner Tube Sub-Assembly. This showcases the workings of the inner tube sub-assembly, which will move to raise and lower the top clamp.

2) *Outer Tube Sub-assembly*

The Outer tube sub-assembly (Figure 1) is the main structural component that houses the Inner tube sub-assembly and the Handle sub-assembly. This assembly is composed of the Cap, Spring, Spring Plate, Lever Box, Bottom Clamp and the Outer Tube. The outer tube has two handles perpendicular to the main body which function as a static force to counteract the pulling force on the handle and inner tube assembly. Below the two static handles, parallel to the main body, are two elongated slots opposite each other which provide an opening for the Handle sub-assembly to attach to the inner handles.

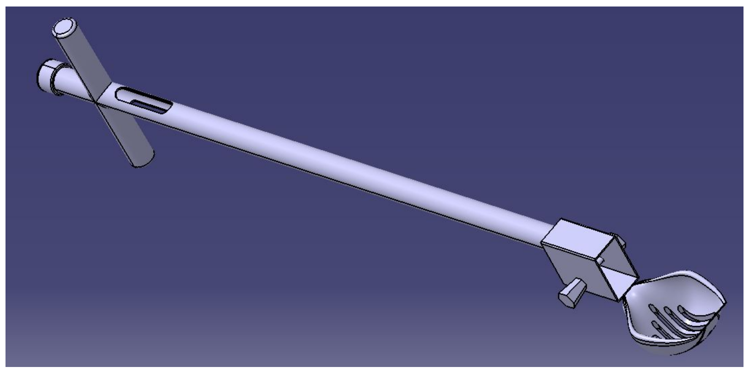

Figure 3: Main Outer Tube Assembly. This assembly comprises the total length of the DRTFLOSS

A cap is positioned on the top of the outer tube, which provides a static counteracting force when the spring is compressed from the astronaut's pulling motion (see Figure 3). The cap is threaded to the tube to provide easy access to the spring and a strong attachment between the two. At the lower end of the Outer tube, the Lever box and Bottom Clamp are attached via a weld; this box houses the Lever and Lever action linkage and allows the lever to pivot axially about the Pin and Pin Cap connection through a small hole drilled in each side.

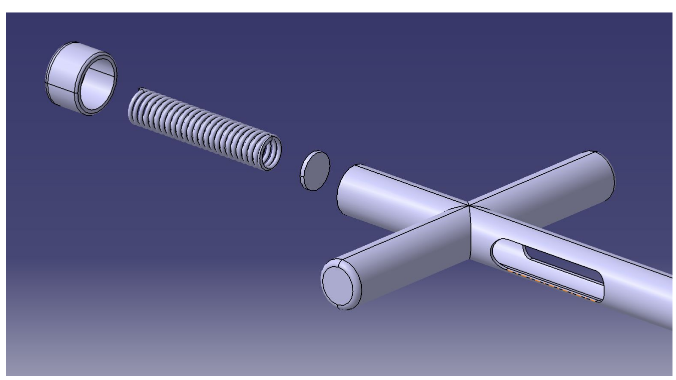

Figure 4: Outer Tube Exploded View. This detailed separation of the top cap from the "T" shaped bar reveals the interior spring and spring plate of the DRTFLOSS outer tube.

3) *Handle Sub-assembly*

The handle sub-assembly (Figure 4) is composed of the Handle threaded shaft, Handle Shaft, and two Handle Couplers. The Handle Threaded shaft and Handle shaft each have a Handle Coupler that align concentrically with the thread and hole for each. These two separate subsystems then screw together through the elongated hole on the Outer Tube and the drilled hole on the inner tube until the circular cut out on both Handle Couplers become flush with the Inner tube. The purpose of the handle couplers is to eliminate any pinch points that may come into contact with the EVA gloves.

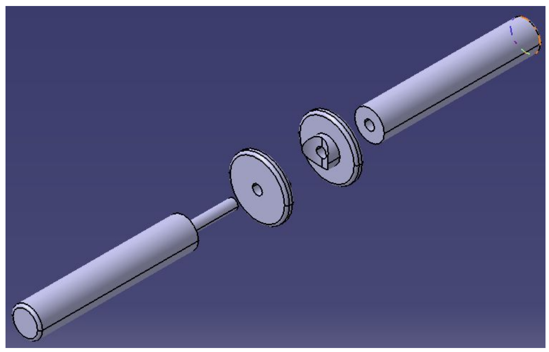

Figure 5: Handle Sub-Assembly. The sub-assembly of the handle clearly shows the connections between the threaded handle shaft, handle shaft, and both handle couplers.

2. Manufacturing Processes

1) *Lathe*

The lathing process will be used for the aluminum rods that will compose the Main Pin, linkage Pins, and Handle sub-assembly. This will be achieved on the Embry-Riddle Aeronautical University (ERAU) campus by the team members.

2) *Welding*

Welding is the main method that will be used for connecting static components such as the Lever Box, Bottom Clamp, Inner Tube Adapter, Inner Tube and Outer Tube. We will be using both aluminum-6061 and stainless steel welding techniques on the Outer and Inner tube sub-assembly. This will be achieved on ERAU campus.

3) *Drilling/CNC*

The lever box will require drilling holes to allow an axis of rotation or a simple connection. This will be achieved on ERAU campus.

4) *Bending*

The team will need to bend the lever box. Aluminum-6061 is fairly malleable and this will be done using a metal bender. This will be achieved on campus.

5) *Sand Casting*

Sand casting will be used to make the specialty clamp pieces. The parts will be 3D printed to make the sand mold and molten aluminum will be poured in. This will be contracted.

6) *Tap/Die*

The team will need to tap and die the cap on the top of the device and the pin that is the main pivot point for the lever mechanism. This will be achieved on campus.

3. Materials

1) *Aluminum-6061*

The team chose aluminum-6061 for all parts except the Spring and Cotter Pins due to the balance between strength and manufacturability. This aluminum alloy is easier to weld, but also has a tensile yield strength of 276 MPa. It has a thermal conductivity of 167 W/mK and is solid up to 582 ^{o}C. It has an electrical resistivity of 3.99 x 10^{-6} ohm cm [1].

2) *Stainless Steel Type 304*

The team chose this type of stainless steel because it is the most common, not needing any specific attributes, this works just fine. The spring and the cotter pins will be made with this steel. This series has a tensile yield strength of 215 MPa, a thermal conductivity of 16.2 W/mK, and is solidus up to 1400 ^{o}C. It also has an electrical resistivity of 7.2 x 10^{-5} ohm cm [2].

3) *Tef-Gel*

The team chose this lubricant based on the allowed lubricants on the NBL approved lubricants list and the temperatures that will be experienced on the moon, as well as the interactions with the materials we will be using. This lubricant can experience temperatures as high as 204 ^{o}C and has no dropping point. It is perfect for moving components and is non reactive with aluminum [3].

4. Finite Element Analysis (FEA)

To ensure the safety of the astronaut and the durability of the device, the team performed FEA via CATIA V5 on three pivotal parts that were determined to experience a significant load. A distributed load of 100 lb*in was placed on the working surface to determine when the Lever and Joint Linkage Arm will yield or fracture and 50 lb*in on the pin. The data gathered is shown below in Figures 6, 7 and 8.

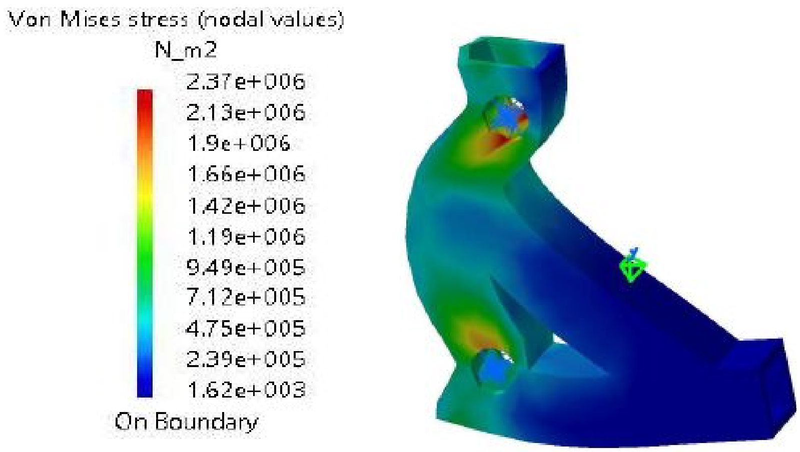

Figure 6: CATIA V5 FEA Lever Analysis

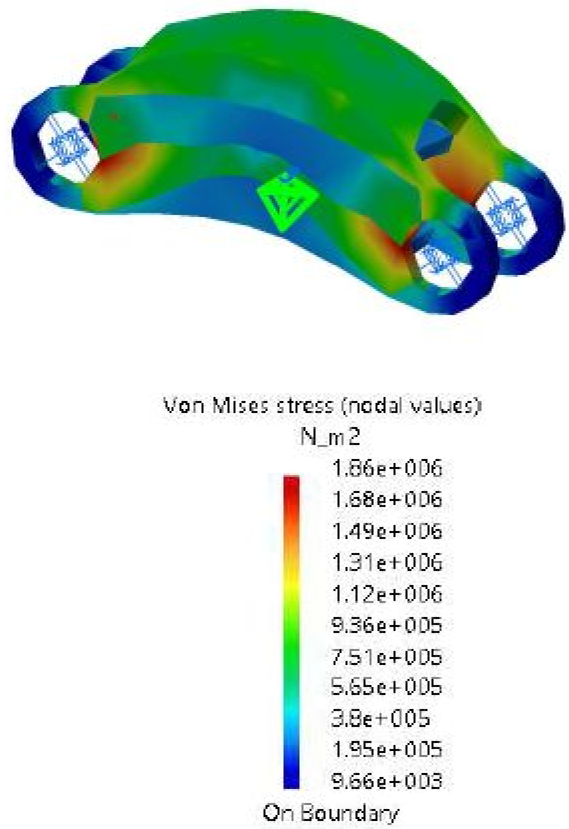

Figure 7: CATIA V5 FEA Joint Linkage Arm

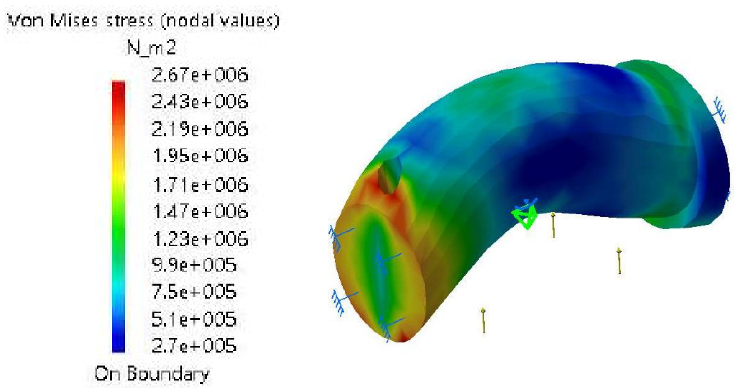

Figure 8: CATIA V5 FEA Linkage Pin Analysis

As seen in the analysis, the parts tested can withstand a high amount of stress before yielding. When comparing these maximum stress values obtained to the yield stress, all of the parts did not exceed the limit. These values are more than adequate for the scope of this device and will ensure functionality on the moon. Since the moon has no atmosphere and can reach extreme temperatures, aluminum and steel were chosen because of the thermal durability of these metals.

5. Environment

Given the dusty environment of the moon, the infringement of dust was taken into consideration in the design process. The device was designed to be completely disassembled should it get full of lunar dust. For ease of assembly and environmental resilience, the handles around the inner tubing are designed to be screwed into one another through the tube itself. Metal buffers have been placed on either side of the inner tube so as to avoid excessive dust interference and protect the EVA gloves from pinching. The bottom scoop designed for collection of samples has thin holes in it. These holes are small enough that loose samples of the size desired will not fall through, but substantial enough that loose dust can be sifted through the bottom.

Additionally, the lubricant used, Tefgel, was chosen because of its resilience to high thermal versatility. Due to the wide range of temperatures present on the moon, it is essential to ensure the durability of all of our materials. Aluminum 6061 and stainless steel have a high Technology Readiness Level (TRL) due to their repeated successful testing in low-gravity and lunar environments.

6. Design Requirements Compliance

Table 1: Challenge Requirements. For ease of comparison, the following table lists all baseline requirements for the dust-tolerant lunar sample device challenge and the satisfactory aspects of the DRTFLOSS.

Number	Requirement Description	Compliance Statement
1	The device shall be able to pick up float samples ranging 0.5" to 3" in diameter.	Encapsulating mechanism will only allow samples between 0.5" and 3" to be collected.
2	The device shall be able to function as intended after being fully submerged in lunar dust simulant. The device will be fully submerged, removed from the lunar dust simulant, and then cycled 10 times.	The DRTFLOSS is designed to allow lunar dust to enter and easily fall out due to large tolerance between surfaces.
3	The device shall use only manual power.	The device uses a hand-squeeze, pull to open mechanism.
4	The device shall be a minimum of 30 and a maximum of 35" in length to allow the subject to collect a float sample without bending over.	The total length will be 35".
5	The device must be operable with EVA gloved hands (like heavy ski gloves).	The hand-squeeze, pull to open mechanism requires only 1" of finger/hand movement.
6	The total weight of all parts you provide should be less than 3 lbs.	All parts will be optimized for a maximum strength and weight of 2.73 lb.
7	Tools must not have holes or openings which would allow/cause entrapment of fingers.	Hole for handle is protected with hand guard to prevent against entrapment.
8	Tools should be made from Aluminum 6061, Aluminum 7075, Stainless Steel (any series), or Teflon. Any other materials must get prior approval from the EVA Tools POC*.	All parts will be made from stainless steel and aluminum 6061.

9	Lubricants must be selected from the NBL approved lubricant list or a waiver must be granted (Approved Materials List).	Lubricant / Tef-Gel PTFE 9002-84-0 will be used as the lubricant.
10	There shall be no sharp edges on the tool.	All square or sharp edges will be filleted down to prove no puncture risk.
11	Pinch points should be minimized and labeled.	Pinch points are minimized using finger guards on handles and pinch points in pivoting mechanism(inside box) will be labeled.

C. Operations Plan

1. Preliminary Testing Operations Plan

Our testing prior to official testing at NASA NBL will occur on and around the ERAU Daytona Beach campus with members of the Microgravity Club. We will take our device and fully submerge it in the sand, then remove and pick up a loose sample of .5" diameter. We will then repeat this process two more times, cycling the same, but picking up samples of 2" in diameter and 3" in diameter.

2. Operation Procedure

1) The operator will wrap their thumb around the stationary handle with their fingers actuating the dynamic handles.
2) The operator will pull back with their fingers on the smaller handle. This causes the pivot mechanism at the bottom to open the non-static scoop head, enabling it to collect a sample.
3) Locate a suitable lunar sample ranging from 0.5" to 3.0" in diameter.
4) Place the device so that the static bottom clamp is against the sample with the opened top clamp hovering over the sample.
5) The operator slowly releases their fingers back to the starting position causing the pivot mechanism to close. This will pull the sample between the two clamps and secure it.

3. Testing Outline

Testing of the dust tolerant loose sample device will be done at ERAU and at local beaches. The device will be tested against all of NASA’s requirements and for functionality underwater for testing at NBL facilities.

1) *Sample Capacity*

We will test our device by picking up samples at Daytona Beach with diameters of .5", 2", and 3" after cycling the device through soft, fine grain sand (as opposed to packed, wet sand).

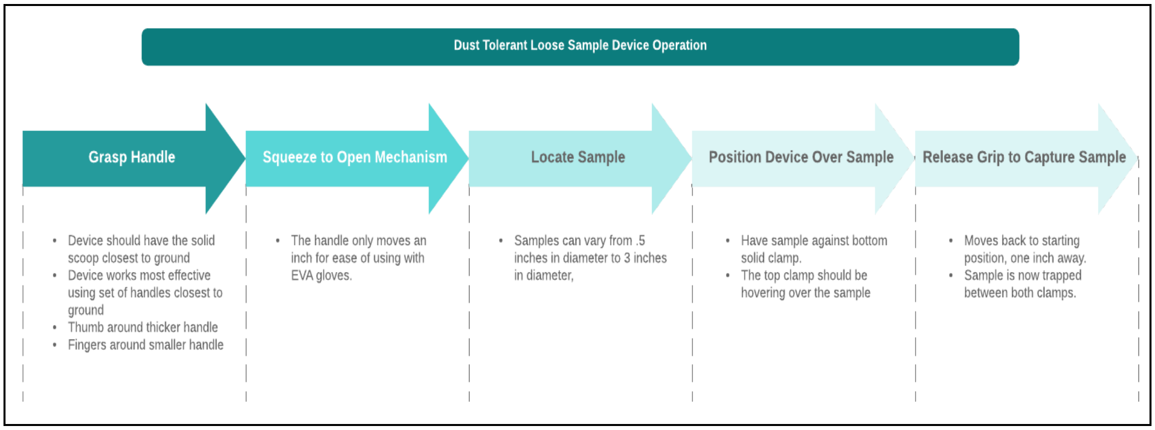

Figure 9: DRTFLOSS Operation Flowchart. The operations plan in the form of a flowchart is a simple representation of how the DRTFLOSS will obtain its loose surface sample.

2) *Dust Tolerance*

We will submerge and remove the prototype in and out of the fine-grain sand 10 times which will then be followed by the sample collection testing. That process will be repeated three times, exceeding the amount set by NASA in the project constraints.

(1) EVA Glove Compatibility

(2) All testing will be conducted with a heavy ski glove, hockey glove or mock EVA glove to ensure that the device can be operated with EVA gloves.

4. Troubleshooting/Cleaning

The DRTFLOSS has an open design that allows dirt to flow through the device with a minimal risk of malfunction. There is a high tolerance between the outer tube and inner tube to allow for dirt to pass through the device and come out at the open end of the box. The hinges and pin in the pivoting mechanism will have low tolerances and will be lubricated preventing dust buildup. The DRTFLOSS is designed to come completely apart for cleaning or to deal with any malfunctions while using EVA gloves if needed. At the top of the device there is a cap which can unscrew and give access to the spring for cleaning. By removing the pin on the box at the bottom of the device and unscrewing the handles from each other, the entire inner tube and pivot mechanism can be removed from the outer tube and the entire system can be completely purged of dust. A troubleshooting flowchart (Figure 11) is located in sub-section B in the Appendix.

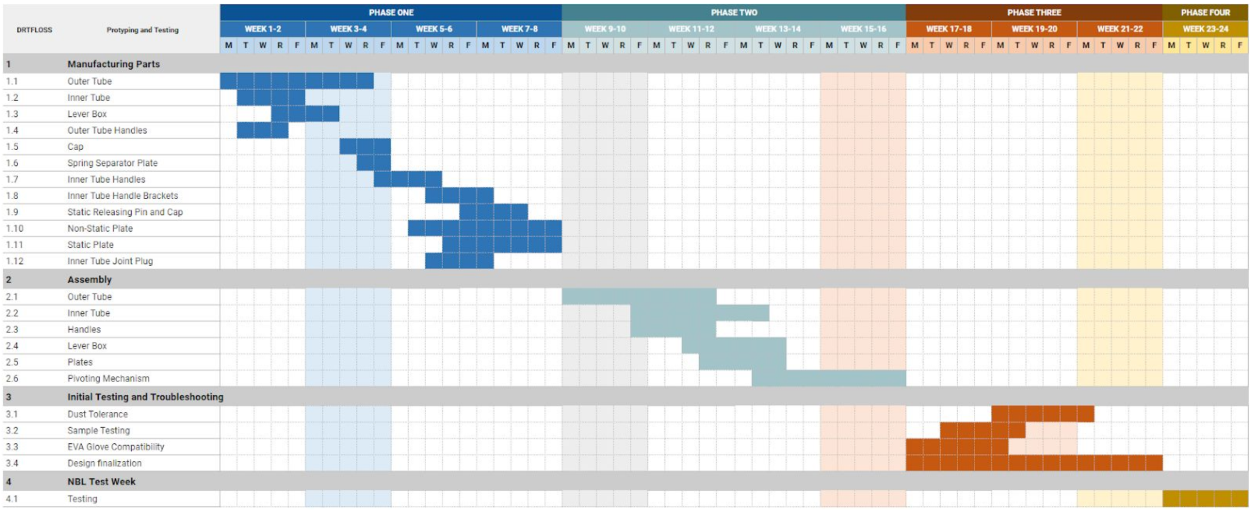

Figure 10: Gantt Chart. For the purpose of tracking the overall manufacturing stage, the gantt chart below breaks up the different levels of production into 4 separate phases. Each phase categorizes a specific set of steps (manufacturing, assembly, … etc.) all the way through test week at the NBL.

D. Safety

With safety at the forefront of NASA's values, and for the overall success of those interacting with the DRTFLOSS, it was critical that all final decisions on its design were made to ensure the health, comfort, and well being of its user and surroundings. Several requirements outlining the general expectations of the device, along with further considerations established by the team, have been organized below (Table 2). In addition, a standard Event Tree Analysis, located in subsection C in the Appendix, details the underlying mechanical and operational hazards which the DRTFLOSS may be subject to experience, while also covering the preventive measures aimed at countering them.

Table 2: Safety Warning Assessment. In addition to addressing the primary safety requirements set by the NASA challenge, the table below provides the DRTFLOSS design team's solutions to a number of further device, user, and environmental safety considerations.

Safety Warning	Indication of Interest	Consequence of Issue	Solution
Device must not have holes or openings exposed to its user	**User Safety Requirement**	Could cause entrapment of fingers or user injury	Slots and openings of the device are small in comparison to EVA gloves and sufficiently removed from user-tool interaction
Device shall have no sharp edges	**User Safety Requirement**	Could tear the user's EVA gloves/suit or cause the user injury	Any sharp edges on the tool are concealed or dulled to pose no threat to the user
Device should minimize and label any pinch points	**User Safety Requirement**	Could tear the user's EVA gloves/suit or cause the user injury	Pinch point will be labeled on the handle, while all other pinch points are concealed within the device

Device shall be a minimum of 30" and a maximum of 35" in length to allow the subject to collect a float sample without bending over.	**User Safety Requirement**	Could cause user discomfort and unnecessary delay of operation	Length of the device from handle to claw is long enough to allow the user comfort and efficiency
Device shall maintain reusability	**Environmental Safety Requirement**	Would create unnecessary waste and labor on extra manufacturing/ disposal	Durability in design and material choice ensures reusability of device
Device shall allow user to easily remove sample	**User Safety Consideration**	Unnecessarily difficult sample extraction method could delay operation and confuse user	Squeeze-release spring compression claw allows user to quickly extract sample
Device shall maintain original conditions of sample upon collection	**Sample Safety Consideration**	Could damage or change characteristics of original sample	Collection claw occupies original sample in a secure space
Device shall expel all unnecessary dust collected with sample	**Sample Safety Consideration**	Would capture unnecessary lunar dust, contaminating the desired sample	Small slits in collection claw wall allow lunar dust to pass through collection space while retaining original sample
Device shall leave no waste or excess debri on the lunar surface	**Environmental Safety Consideration**	Could contaminate the lunar surface with unintended or harmful waste	Device operation produces zero waste
Device shall release no waste or excess debri into space	**Environmental Safety Consideration**	Could be releasing unintended or harmful waste into space	Device operation produces zero waste

E. Technical References

[1] Allton, Judith Haley. "Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers." *Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers*, NASA JSC, 1989.

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II. Outreach Section

A. Outreach Objectives

1. Develop, stimulate, and cultivate interest in the Micro-g NExT challenge and in Science, Technology, Engineering, and Mathematics (STEM) fields of students (including elementary, middle, and high school students) in the local community.
2. Spread awareness of the NASA Micro-g NExT Project to each college at Embry-Riddle Aeronautical University: College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation.
3. In the event of successful completion of the project proposal, share the results of the project and opportunities within NASA, specifically in regards to Micro-g NExT through a project presentation and demonstration.

B. Outreach Audience

The goal of the team is to reach the maximum number of people as possible in order to maximize the positive effects that the project can have on the local community. This target audience can be broken down into three broad categories: students in the local community; students and faculty at ERAU; and the general public.

Students in the local community of Daytona Beach and the surrounding areas are the main focus of the Microgravity Club' outreach. This group includes students at local elementary and high schools. The local middle school that we will be pairing with is Silver Sands Middle School, which is located in Port Orange, Florida. Specifically, we will be working with their fifth grade students. The goal of the outreach to the fifth grade students at Silver Sands Middle School is to increase their exposure to STEM, in order to develop an interest in these areas at a young age, and teach these students about the opportunities that are available to them even at such a young age.

Additionally, outreach will be directed to the ERAU community. This goal of outreach to the ERAU community is for increased awareness of the Micro-g NExT project on the campus. More specifically, the goals for outreach to the ERAU community can be represented in two generic categories: faculty and students. Through outreach to the ERAU faculty, the team is hoping to establish further relationships with faculty members that are interested in the Micro-g NExT project. These connections that are made will help to establish relationships that can provide mentorship and resources for the project. Additionally, outreach to ERAU faculty will allow for connections to each of the different colleges at Embry-Riddle: the College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation. The connections to each of these colleges will help to facilitate interdisciplinary collaboration, and will assist in an increased collaboration of the sharing of resources on campus. Through outreach to the students at ERAU, the team is hoping to promote interest in the Micro-g NExT Challenge. Increased interest will promote support of the team and will allow for more individuals to become involved with the Micro-g NExT challenge this year, and in the years to come at ERAU.

The final focus audience of the outreach is the general public. The purpose of the outreach to the general public is to broaden the scope of the team's outreach to include individuals that may not be directly interested/linked to these fields that are being worked in so closely. By sharing the project with the general community, it opens up more doors for involvement and collaboration in ways that the team has not thought of themselves.

C. Specific Plans for Activities

In order to meet the objectives for the outreach listed in the above section, the team currently has a variety of activities planned, all of which are listed below. The activities listed follow the same order as the objectives listed in Section A.

1. Outreach to Students in the Local Community

The first activity planned will be to hold a small competition amongst sixth grade teams Silver Sands School which will require them to use basic materials to craft a bottle rocket. The goal of the competition will be to see which rocket goes the highest (exact procedures and materials for this competition will be listed at the end of this section). The goal of such a competition will be to educate students on the basic principles involved with the construction of a rocket, such that they will have a better understanding of the processes used in the design and development of real rocket, while also getting to have a hands-on arts and crafts activity. While learning about the uses and construction of rockets, the students will also learn more about space travel as a whole, thus tying into the Micro-g NExT Life Raft challenge, as the students will also learn about what happens in the event of an emergency on a rocket. In addition, this activity ties into the Florida 6th grade science curriculum standards of "exploring the law of gravity," as rockets and space travel are both very much affected by this law. Learning about ways that gravity interacts with rockets will supplement and build upon the knowledge they've been learning throughout their sixth grade year.

To conduct this activity, the 5E model (Engage, Explore, Explain, Elaborate, and Evaluate) will be applied to create the following lesson plan:

1) *Engage:* Students will listen and participate in a presentation about rockets and how they are used and made.
2) *Explore:* The students will identify and develop knowledge of the various properties of rockets through their construction of their bottle rockets.
3) *Explain:* The students will build their bottle rockets and will be able to successfully demonstrate their understanding of the properties of rockets by discussing their designs.
4) *Elaborate:* The students will learn more about gravity's effect on rockets and the emergency procedures involved in the use of rockets.
5) *Evaluate:* The students will demonstrate their understanding of rockets and gravity by being able to discuss what they have learned through some basic closing questions.

a. *Materials*

Water bottles, bicycle pump, scrap cardboard

b. *Procedure*

(1) Use the materials provided to design and build a bottle rocket.
(2) Compete to see who's rocket can reach the highest.
(3) Discuss the properties of the rockets, gravity, and emergency procedures and what worked and what did not.

2. Spreading Awareness at ERAU

A focus of the Microgravity Club's outreach will be outreach toward the ERAU Community. The first step that the team will make in order to connect with various student and faculty members will be posting an advertisement, shown in the appendix, around campus. In each of the colleges at ERAU (College of Engineering, College of Arts and Sciences, College of Business, and College of Aviation) there are digital advertisements presented in each college's atrium. This advertisement will be posted in each of these colleges in order to spread awareness of the project. Additionally, social media will be used to detail the progress of the project, which will assist in outreach to both student and faculty groups. The social media plan discussed in more detail later on in the outreach section.

In order to strengthen the outreach to faculty members, faculty members in each of the different colleges will be contacted detailing the project. One of the goals of Microgravity Club is to establish a group of faculty members that are interested in the Microgravity Club's progress and pursuits in order to increase their network of support and spread awareness of the project. This faculty contact will consist of initial emails to faculty members in each of the colleges, detailing the Micro-g NExT Challenge and what the Microgravity Club's goals for this semester are. After this initial email, interest in becoming involved with the project will be gauged, and any faculty members that are interested in becoming involved in the project will be met with in order to establish a personal relationship between the Microgravity Club and the faculty member. The Microgravity Club will then create an email list consisting of all interested parties, and will send out weekly email updates in order to keep the ERAU community up to date on the progress of the Microgravity Club in the Micro-g NExT Challenge.

In regards to outreach to ERAU students, the Microgravity Club has already begun outreach. On Thursday, September 19, 2019, the Microgravity Club participated in ERAU's student activities fair. At the activities fair, the Microgravity Club presented this year's Micro-g NExT challenge in order to recruit new membership and spread awareness of the project. This event was incredibly successful, as the Microgravity Club was able to talk to numerous students, and additionally received approximately fifty signatures of students interested in becoming involved with the Micro-g NExT challenge. The Microgravity Club will also be submitting articles to the ERAU newspaper, The Avion, detailing the project pursuits, successes, and progress. The Microgravity Club will submit these articles to The Avion once every month. Additionally, the Microgravity Club will be showcasing their project at ERAU's Family Weekend, which will be in February 2020, and Preview Day, which will be in April 2020. At both of these events, the Microgravity Club will be showcasing their design, and talking to prospective and current ERAU students about what the Micro-g NExT Project entails.

In order to strengthen outreach to both ERAU students and faculty, the Microgravity Club will be applying to participate in the Office of Undergraduate Research's 7th Annual Discovery Day, which is ERAU's student research conference, which is currently scheduled for April 2020. At this conference, the Microgravity Club will be able to share a project poster to students and faculty members, which will be incredibly beneficial in spreading awareness of the project at ERAU.

Additionally, the Microgravity Club team will be hosting a workshop for ERAU students providing information and insight on successful methods for completing research projects. During the workshop, the Microgravity Club team will discuss resources available on campus for funding, resources available for manufacturing and operations, and will also discuss the Micro-g NExT Challenge and the resources available in reference to those design challenges. Additionally, the Microgravity ClubF will discuss their project, and will share their knowledge about what practices worked and didn't work for the leadership and members of the team.

D. Social Media Plan

The Microgravity Club will be utilizing social media in order to supplement the project outreach. The two primary social media platforms will be Instagram (@eraumicrog) and Facebook (@eraumicrog). Each of these social media platforms will be updated at least weekly, with the same weekly report that is sent to the network of faculty supports detailed in the above paragraphs. Additional posts will be made on each of these social media platforms with pictures of testing, outreach activities, and images of design manufacturing. Additionally, the Microgravity Club will be utilizing a website (https://sites.google.com/view/eraumicrog) which will serve as another resource for sharing the progress with the public. This website will be updated at the same frequency as the other social media platforms, and will contain records of all of the weekly reports that are shared.

E. Communication Logs

Contacts: Lynn Bartholomew, Principal's Secretary
ljbartho@volusia.k12.fl.us

Communication Logs:

BJ
Bartholomew, Lynn J. <ljbartho@volusia.k12.fl.us>
Wed 10/30/2019 7:16 AM
Mosteller, Zachary J.; Alligood, Kevin G. <KGALLIGO@volusia.k12.fl.us>

Zach Mostellzer will be calling you about an opportunity for STEM outreach from their Club.

Lynn Bartholomew
Principal's Secretary
Silver Sands Middle School
1300 Herbert Street
Port Orange FL 32129
ljbartho@volusia.k12.fl.us
Phone: 386-322-6175, ext. 36422
Fax: 386-506-5042

This communication and any files transmitted with it are confidential and intended solely for the use of the individual or entity to whom they are addressed. If you have received this email in error, please notify the sender immediately. For any other questions, please contact Customer Support at custserv@volusia.k12.fl.us Under Florida law, our e-mail addresses and communications are public records. If you do not want your e-mail address and message content released in response to a public records request, do not send electronic mail to this system. Instead, contact this office by phone or in writing.

III. Administrative Section

A. Test Week Preference

The preferred test week for the team is Test Week 1 - May 18-23, 2020

B. Mentor Request

The Embry-Riddle Aeronautical University Microgravity Club requests the mentorship of Stephanie Johnston. She has been our mentor in previous years and we truly enjoyed her help. It would be an honor to have our club be in contact and mentored by her again this year.

C. Institutional Letter of Endorsement

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

Department of
Mechanical Engineering

Tel: 386-226-6667
Fax: 386-226-6011

October 28, 2019

Micro-G NExT Selection Board
Johnson Space Center
2101 NASA Parkway
Houston, TX 77058

RE: "Statement of Department Chair of Mechanical Engineering" for the 2019-2020 NASA Student Micro-G NExT Design Challenge."

Dear Micro-G NExT Selection Board:

The Department of Mechanical Engineering endorses the 2019-2020 NASA Student Micro-G NExT Design Challenge entitled "Dust-Tolerant Loose Sample Device" proposed by a diverse team of undergraduate students from Embry-Riddle Aeronautical University, Daytona Beach Campus under the advisorship of Drs. Gangadharan, Dikici and Llanos.

We concur with the concepts and methods by which this project will be conducted. We understand that any default by this team concerning any of the Program requirements (including submission of final report materials) could adversely affect the selection opportunities of future teams from Embry-Riddle Aeronautical University at Daytona Campus.

Sincerely,

Eduardo Divo Ph.D..
Professor and Chair, Mechanical Engineering
Embry-Riddle Aeronautical University
Daytona Beach, Florida 32114
Tel: (386) 226-7987
Fax: (386) 226-6011
Email: divoe@erau.edu

embryriddle.edu

D. Statement of Supervising Faculty

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

Department of
Mechanical Engineering

Tel: 386-226-6667
Fax: 386-226-6011

October 28, 2019

Micro-G NExT Selection Board
Johnson Space Center
2101 NASA Parkway
Houston, TX 77058

RE: "Statement of Department Chair of Mechanical Engineering" for the 2019-2020 NASA Student Micro-G NExT Design Challenge."

Dear Micro-G NExT Selection Board:

The Department of Mechanical Engineering endorses the 2019-2020 NASA Student Micro-G NExT Design Challenge entitled "Dust-Tolerant Loose Sample Device" proposed by a diverse team of undergraduate students from Embry-Riddle Aeronautical University, Daytona Beach Campus under the advisorship of Drs. Gangadharan, Dikici and Llanos.

We concur with the concepts and methods by which this project will be conducted. We understand that any default by this team concerning any of the Program requirements (including submission of final report materials) could adversely affect the selection opportunities of future teams from Embry-Riddle Aeronautical University at Daytona Campus.

Sincerely,

Eduardo Divo Ph.D..
Professor and Chair, Mechanical Engineering
Embry-Riddle Aeronautical University
Daytona Beach, Florida 32114
Tel: (386) 226-7987
Fax: (386) 226-6011
Email: divoe@erau.edu

embryriddle.edu

E. Statement of Rights of Use

As a team member for a proposal entitled "DRTFLOSS" proposed by a team of undergraduate students from Embry-Riddle Aeronautical University, I will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any data contained in this proposal in whole or in part and in any manner for Federal purposes and to have or permit others to do so for Federal purposes only.

As a team member for a proposal entitled "DRTFLOSS" proposed by a team of undergraduate students from Embry-Riddle Aeronautical University, I will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States an invention described or made part of this proposal throughout the world.

Signed:

David Jefts – President

Austin Dunbar – Vice President

Christopher Rivera – Treasurer

Greta Fergus – Secretary

Zach Mosteller – Outreach Team Lead

Hunter Hatchell - Student Advisor

Justin Randall – Student Advisor

Riley Cox-Gross – Team Lead

Brian Richardson – Member

Sarah Baird – Member

Nathan Kopka – Member

Donovan Mueller – Member

Jonathan Seiler – Member

Brock Steinfedt – Member

F. Funding and Budget Statement

1. Estimated Funding Statement

Funding Source / Sponsor	Total Possible Funding (USD $)
Microgravity Club Savings	$380.00
Membership Dues ($20 x 30)	$600.00
IGNITE (Undergraduate Research Program)	$1,000.00
Aerospace Engineering Department	$500.00
ERAU SGA Annual Fund	$2,500.00
Florida Space Grant Consortium (FSGC)	$3,000.00
Total	**$4,980.00**

2. Estimated Expenses Statement

Items	Link / Reference	Quantity	Price Per	Total Cost
Design Materials				
Cap HandleCouplers Handle Parts Inner Tube Lever Box Lever Outer Tube Spring Clamps Cotter Pin Lubricant	Link Link Link Link Link Link Link Link Link Link Link	1 1 1 1 1 1 1 1 1 1 1	$5.70 $14.92 $17.88 $27.95 $73.04 $5.67 $30.35 $9.00 $13.24 $3.74 $39.00	$5.70 $14.92 $17.88 $27.95 $73.04 $5.67 $30.35 $9.00 $13.24 $3.74 $39.00
Manufacturing Costs				
Linkage Pin	Link	1	$2.66	$2.66
Outreach Materials				
				$100

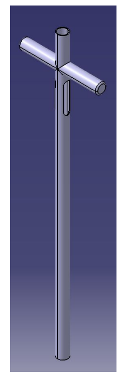
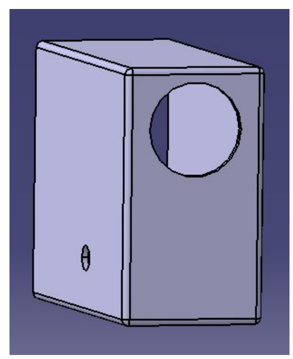
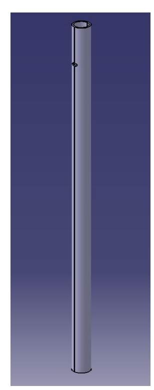
Travel				
Gas				$600.00
Hotel				$3,500
Food		84 meals	$15	$1,260
Total				**$5,703.15**

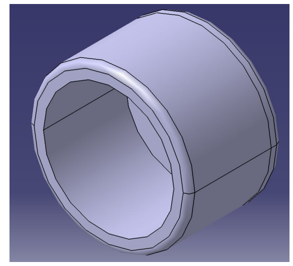
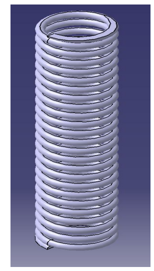
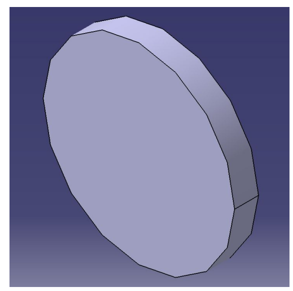
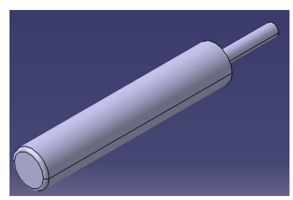
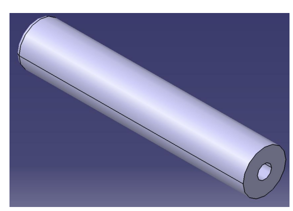
G. Parental Consent Forms

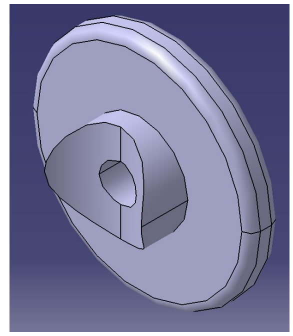
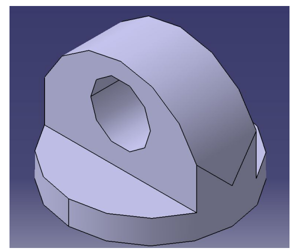
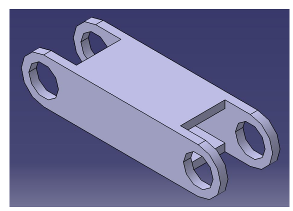
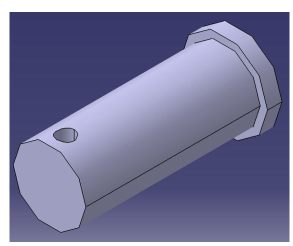
We do not have any team members who are below the age of 18.

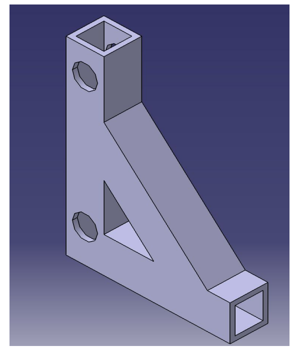
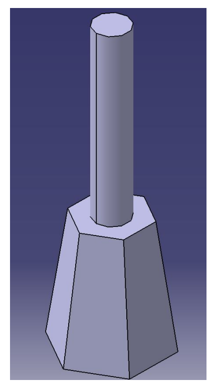
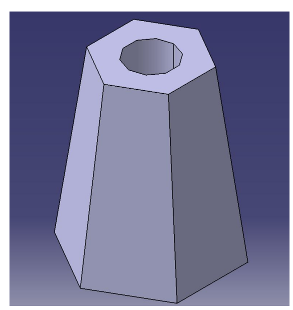
IV. Appendix

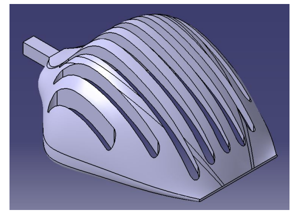
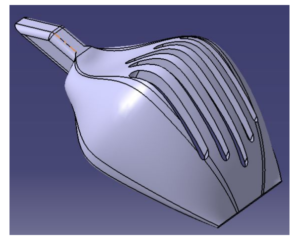
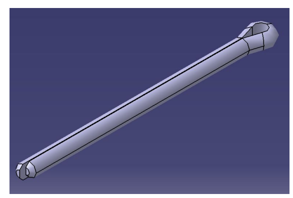
A. Bill of Materials

Part #	Part Description	Material	Manufacture Plan/ Purchased at	Picture	Source
1	Outer Tube- It is hollow and that contains the rest of the parts. It has a threaded top so the cap can screw onto it.	Aluminum 6061	Tube will be purchased from McMaster-Carr. Symmetrical elongated holes will be drilled. A die will be used to make the male version of threading for the Cap.		https://www.mcmaster.com/89965k531
2	Lever Box - Welded to the bottom of the outer tube. It contains the pivoting mechanism. It has a hole for the Static releasing pin and cap.	Aluminum 6061	Metal Sheet will be purchased from Metals Depot. It will be cut, bent, welded and drilled to meet constraints.		https://www.metalsdepot.com/aluminum-products/6061-aluminum-sheet-plate
3	Inner Tube- It is hollow and has a pinhole for the inner handles. It rests inside the outer tube.	Aluminum 6061	Tube will be purchased from McMaster-Carr. A hole will be drilled to fit the inner tube handle thread.		https://www.mcmaster.com/89965k641-89965K64

4	Cap - Has a threaded interior and is to be attached to the top of the device.	Aluminum 6061	A standard Aluminum Cap will be purchased from McMaster-Carr and will then be threaded on the inside.		https://www.mcmaster.com/9275k142
5	Spring - Requires a force of 10 lbs to move one inch. Located between cap and spring separator plate.	Stainless Steel	Purchased from McMaster-Carr.		https://www.mcmaster.com/springs
6	Spring Separator Plate - Solid thin disk with the purpose of not letting the spring slip over the inner tube.	Aluminum 6061 ¾"Round Bar	Round Bar will be purchased from McMaster-Carr. A disk will then be cut out.		https://www.mcmaster.com/9015t111
7	Handle Threaded Shaft - Solid aluminum round bar with one threaded shaft protruding from one side.	Aluminum 6061 ¾" Round Bar	Round Bar will be purchased from Metals Depot. It will then be tapped and hollowed on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar
8	Handle Threaded - Solid aluminum round bar with one small hole drilled and tapped at one end.	Aluminum 6061 ¾" Round Bar	Round Bar will be purchased from Metals Depot. be threaded and hollowed on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar

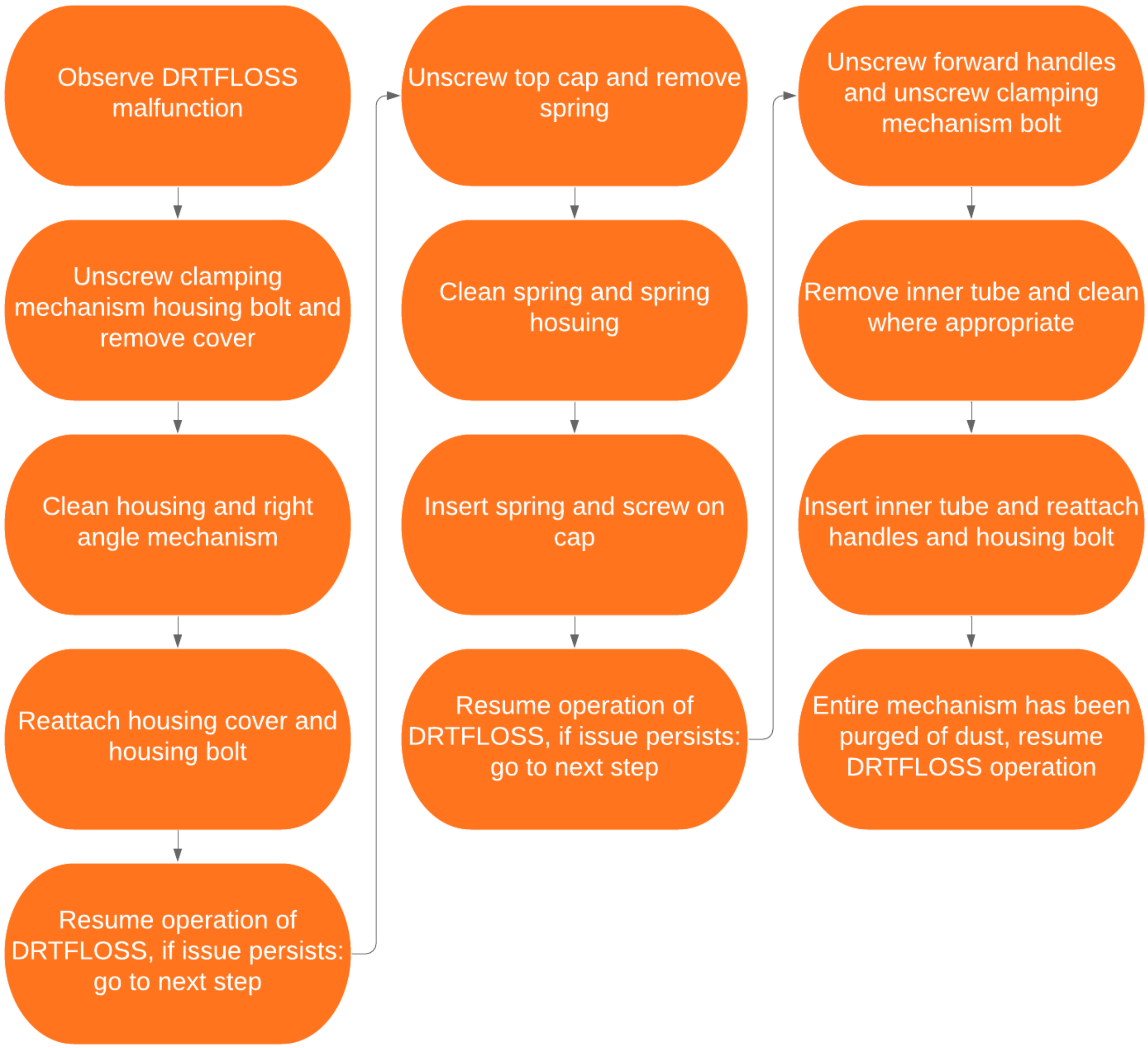
9	Handle Coupler (2) - Goes between the Handle Threaded, Handle threaded shaft and Inner Tube. The side not touching the handles will have a concentric cut-out to remain flush with the inner tube.	Aluminum 6061 1-½" Round Bar	Round Bar will be purchased from Metals Depot. It will then be made on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar
10	Inner Tube Adapter - Is a cylinder that is welded to the inside of the inner tube, with the joint end able to receive the main linkage joint and a linkage pin.	Aluminum 6061 ¾" Round Bar	Round Bar will be purchased from Metals Depot. It will then be made on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar
11	Joint Linkage Arm - Between inner tube pin plug and pivoting lever.	Aluminum 6061	Metal Sheet will be purchased from Metals Depot. It will be cut, bent, welded and drilled to meet constraints.		https://www.metalsdepot.com/aluminum-products/6061-aluminum-sheet-plate
12	Linkage Pins(2) - simple round bar	Aluminum 6061	Round Bar will be purchased from Metals Depot. It will then be made on a lathe.		https://www.mcmaster.com/8974k28-8974K261

13	Lubricant - For joints located at the pivoting mechanism.	Tef-Gel PTFE 9002-84-0	Will be ordered online.		https://www.amazon.com/ref=nav_logo
14	Lever - It is an L bracket with a support truss at the corner to relieve stress.	Aluminum 6061 Square Tube	Square tubing will be purchased from McMaster-Carr. It will then be cut and welded.		https://www.mcmaster.com/6546k48
15	Pin - This pin will hold the lever in the lever box and allow it to pivot.	Aluminum 6061 ¾”Round Bar	Round Bar will be purchased from Metals Depot. It will then be made on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar
16	Cap - The one side of the cap has a pin coming out of it with the end of the pin having threads to receive the other cap.The caps have the shape of expo marker caps for easy removal.	Aluminum 6061	Round Bar will be purchased from Metals Depot. It will then be made on a lathe.		https://www.metalsdepot.com/aluminum-products/aluminum-round-bar

17	Top Clamp - Will have tongs that allow dust to flow out while keeping sample inside. Will have metal strand connecting the ends of the tongs for support.	Aluminum 6061	This part will be sand casted. It will be contracted from Deeco Metals		https://www.deecometals.com/Request-for-Quote-Contact-Us
18	Bottom Clamp - In the shape of scoop that will be welded to the lower part of the box.	Aluminum 6061	This part will be sand casted. It will be contracted from Deeco Metals		https://www.deecometals.com/Request-for-Quote-Contact-Us
19	Cotter Pins - Will lock linkage pins in place	Stainless Steel	Purchased at McMaster-Carr.		https://www.mcmaster.com/98401a915

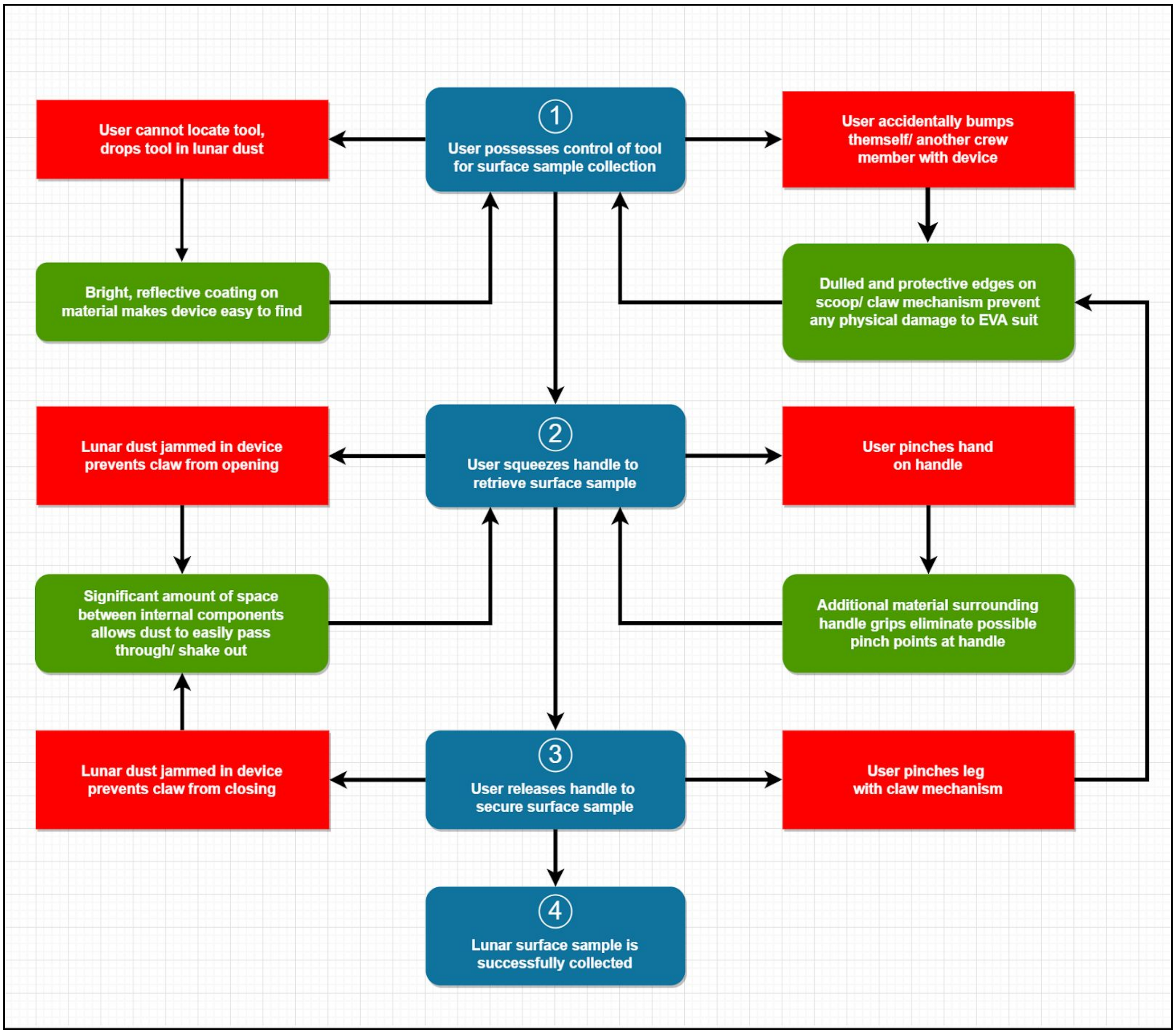
B. Troubleshooting Flowchart

In the event that the DRTFLOSS experiences an issue mid-operation, the following guide will be used to swiftly resolve the problem and continue with the mission.



C. Safety Event Tree Analysis

This diagram of the basic operating process is accompanied by a series of possible hazardous events that the DRTFLOSS user could experience in order to display the solutions designed to prevent them from occurring.



D. Final Exploded Assembly