Lunar Sampling Pivot Device (LSPD)

Lunar Surface Operations - Dust Tolerant Pivot Mechanism

Lunar
Sampling
Pivot
Device

ERAU Microgravity Club

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I. Technical Section

A. Abstract

This project will involve the design and development of a dust tolerant pivot mechanism for use on the lunar surface. This mechanism must be powered manually. The pivot mechanism will be implemented using specially designed, correlated programmable magnets (polymagnets), allowing for a simple and passive mechanism design that locks at 0°, 45°, and 90°. The use of polymagnets rather than conventional gears or other mechanical locking mechanisms minimizes the impacts of lunar dust on the pivot operation. The main components of the device will be built using Aluminium 6061. The device will be tested for performance capabilities in a lunar dust simulant to ensure its performance in the simulated lunar environment at the Neutral Buoyancy Laboratory (NBL).

B. Design Description

1. General Design Description

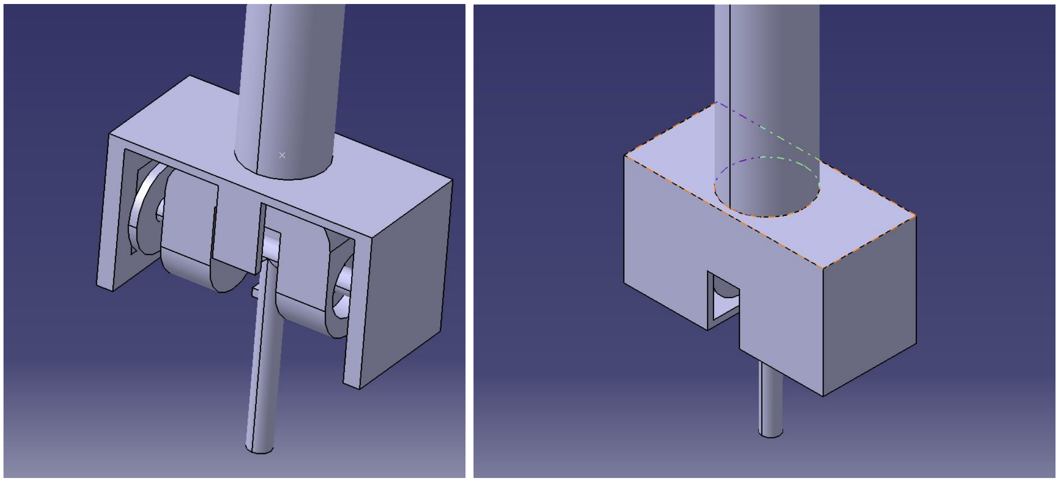

Figure 1: CATIA 3D model of the fully assembled locking mechanism in the 90° orientation with and without a side panel to better view the internal components

The Lunar Sampling Pivot Device (LSPD) is designed to actuate from 0° (horizontal tool head orientation) to 90° (vertical tool head orientation) and locks at 0°, 45°, and 90°. The physical structure for the pivot mechanism is built using Aluminium 6061. The astronaut will hold the device upside down so that one hand can be used to stabilize the device while the other hand manually applies force to the tool head, attached to the small vertical cylinder at the bottom of Figure 1. The applied force will torque the T shaped rod attached to the circular programmable magnets (polymagnets). The circular polymagnets will rotate and repel the square polymagnets encased within the central body to the max distance of 1.5 mm at ± 22.5°, and reattach at the next preferred orientation, locking the tool head in that orientation. The T-Rod is able to rotate freely on its axis because it is attached to the fork via two sealed stainless steel ball bearings, though it is restricted to a 90° rotation by the slot on the external case. This design maximizes the dust tolerance of the pivot mechanism by removing any mechanical parts that can be clogged with lunar dirt or dust particles. The magnets are strong enough to work even if dust gets inside the tool or between the magnets. The ball bearings used for the rotation of the tool head are completely sealed off from the rest of the tool and lubricated to minimize clogging of the ball bearings. The device is designed to have a detachable tool head, such that various tool heads may be accommodated by the pivot mechanism but the prototype to be tested at the Neutral Buoyancy Laboratory (NBL) will only be tested with the default scoop head attachment.

2. Requirement Compliance Matrix

Table 1: Requirement Compliance Matrix

#	Requirement	Compliance Section
1	The scoop head shall be able to pivot to 0°, 45°, and 90° and lock in place at each position. Other positions between 0° and 90° are acceptable but not required.	B.1
2	The pivot mechanism shall be operable with one hand (the other hand can be used to rotate the scoop head or stabilize the handle).	B.1
3	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.	C
4	The device shall use only manual power.	B.1
5	The device shall be a minimum of 30” and a maximum of 35” in length (in the 90° position) to allow the subject to use the scoop without bending over.	B.6
6	The device must be operable with EVA gloved hands (like heavy ski gloves).	C
7	The total weight of all parts you provide should be less than 3 lbs.	B.8
8	Tools must not have holes or openings which would allow/cause entrapment of fingers.	D
9	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*.	B.1
10	Lubricants must be selected from the NBL approved lubricant list or a waiver must be granted (Approved Materials List).	B.4
11	There shall be no sharp edges on the tool.	D
12	Pinch points should be minimized and labeled.	D

3. Programmable Magnets

The main technology behind this design is the polymagnet. Magnetic attraction and repulsion are utilised to define the functions of the polymagnets. Since the mechanism is required to rotate freely between 0 and 90 degrees, and also lock in place, the use of magnets would at first seem counter-intuitive. This idea works due to the use of a special type of magnet called a correlated magnet. These magnets are designed such that the magnetic field can be manipulated to suit various shapes, and can be magnified or suppressed using various configurations. The correlated magnets to be used in this design are a proprietary technology manufactured by a company called Polymagnet® Correlated Magnetics. The Polymagnets are manufactured based on CAD and CAM so that customers can design and purchase polymagnets with exact specifications. The magnetic field only exists within the contours of the given shape and is negligible outside the shape specified. This minimizes the interference caused by the magnet on external systems (Eliason).

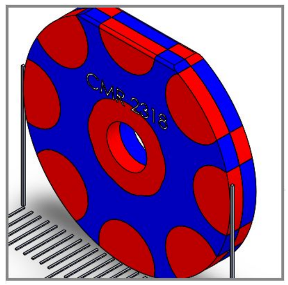

Figure 2: A polymagnet with eight attraction orientations, the red represents south poles and the blue represents north magnetic poles ("Polymagnet Catalog")

Eight total divisions allow for full rotation with locking positions in 45° increments. When implemented with the full LSPD design, only three of the locking positions will be used, one at each 45° increment. The polymagnets can be designed for various angle increments, but due to the required constraint of a 45° orientation, the next set of angles that would include 45° would be at a 15° increment of attraction. This would require 24 north and south poles along the same size magnet, which are not viable constraints for a magnet of this size. The polymagnet with 8 points of attraction has a normal holding strength of 20 lbf, more than enough to collect lunar samples ("Polymagnet Catalog").

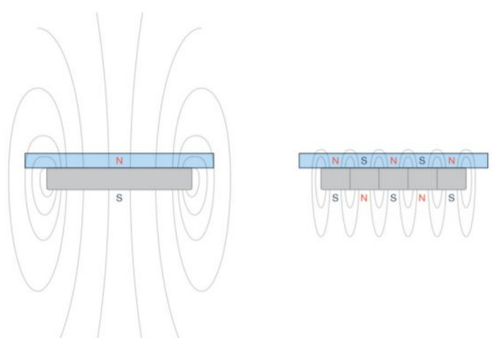

Figure 3: Conventional vs Polymagnet magnetic field representation provided by Correlated Magnetics Research division of Polymagnet® Correlated Magnetics

The pair of polymagnets can produce 20 lbf of holding force because the range of the magnetic field is minimized by creating multiple poles on the same surface, thus resulting in a compact magnetic circuit. The compact magnetic field indicates that at a small distance (0 to 2 mm) the polymagnets will apply a greater force on each other compared to conventional magnets and will have low interference effects on other magnetic fields ("Smart Magnets for Product Design"). Additionally, the strength of magnetic fields are dependent upon exterior temperatures. At sub zero temperatures, magnetic field strength increases, while at high temperatures, magnetic field strength decreases (Yadav). This has to be taken into consideration as lunar surface temperatures fluctuate from 127 °C to -173 °C ("Earth's Moon"). This issue is resolved by using a higher grade magnet that has material properties that can function during high temperatures like N30SH, which has a max operating temperature of 150 °C. More information about magnet grades can be found in Appendix II, as it tabulates the types of magnetic materials that can be used to create polymagnets, provided by Polymagnet® Correlated Magnetics. In order to save money while building the prototype, a lesser grade of magnet will be used, as these magnets are to be tested at the NBL and not the lunar surface. Four of these polymagnets will be used in total, two on either side of the shaft. The two polymagnets connected to the shaft will be countersunk and held in place by screws. The remaining two polymagnets will be riveted to the walls of the case structure. This arrangement will be the pivot point for the mechanism as shown in this document. The shaft will therefore be able to rotate about the axis between the magnets and also be held in place at any of the desired points. Additionally, in order to prevent the shaft from rotating to the wrong side, the mechanism will be manufactured such that a small ridge will manually prevent the shaft (and therefore the tool attachment) from rotating the wrong way.

4. Fork Design

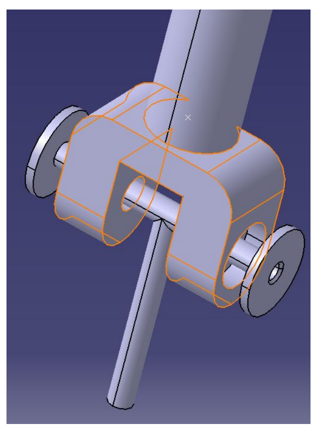

Figure 4: Fork Mechanism

The fork is designed to hold the T-rod in place while absorbing most of the forces taken from the shovel's usage. This property can be seen in the FEA plot in section 7. This fork is also designed to hold two stainless steel ball bearings on either side of the rod for ease of rotation. The fork's block will be machined out of a block of 6061 aluminum using CNC milling, such that the internal holes will be accurate and cost effective. The fillets on edges of the blocks are designed to eliminate sharp edges internally while saving overall weight. The lubricant used in the fork head and the bearing will be Mobil 28. This block will then have a 1.5 inch hollow tube welded to the top of it as to provide the majority of the stability for the system. This tube will also be welded to the casing as seen below. Finite element analysis was used to confirm the design.

5. The Casing (Structure)

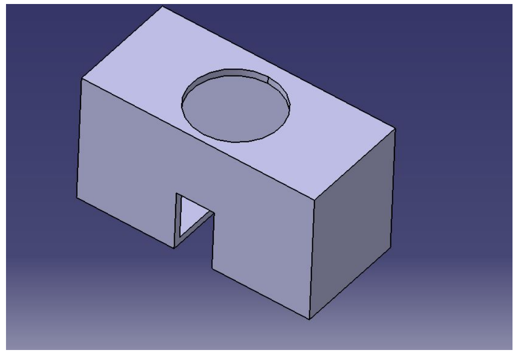

Figure 5: Casing

The casing will contain all of the internal parts, including the rectangular magnets, that will be fixed to the inside walls opposite of one another. This casing will be cut from one sheet of 6061 aluminum and riveted together. The edges will be bent up as to prevent any sharp edges. The rectangular magnets will be fixed in place with an extra sheet of aluminum, and will be made to be slightly smaller than the magnets themselves and riveted to the inside walls. The hole at the top will be cut out with an aluminum hole cutter and deburred to assure no sharp edge presides. The two bent thin members will provide resistance for the T-rod in the form of reactionary forces. These members will prevent excess rotation while also providing a fixed point of contact for the 0° and 90° cases.

6. T-Rod & Magnet Assembly

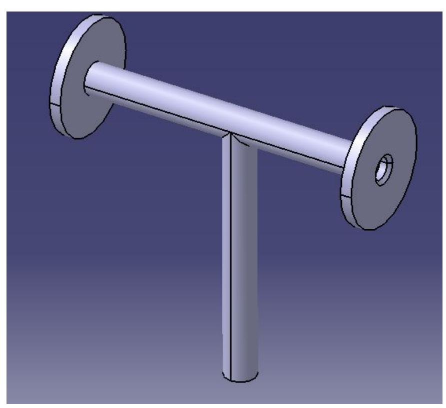

Figure 6: T-Rod & Magnet Assembly

This assembly consists of the T-rod, which will be the structure that the tool head is attached to. It will also be the main rotational member in the pivot mechanism. This rod will be made from a rod welded onto another rod of the same thickness. The rod will be manufactured from 6061 aluminum and will be capable of sustaining the loading required from the shovel's usage. The bottom will have an external thread using a die to fit inside of the tool head. The horizontal rod will be drilled and tapped to allow for the countersunk screws to thread into it, thus fixing the magnets to it. The magnets will be designed by Polymagnet® to account for the different poles and for a hole with a depression to fit the countersunk screws through it. The length of the T-Rod with the scoop attached will be a total of 5 inches below the bottom of the case to abide by requirement 5. The default scoop head in the parts list is a blunt scoop head so that it does not harm the astronauts, whether it's attached or detached from the pivot mechanism.

7. Structural Design Analysis

In order to be sure the design will be structurally sound, CATIA's finite element analysis was used to analyze the critical parts. The fork head and handle is what absorbs the majority of the load set forth by the astronaut. The other part that was critical was the T-rod that hosts the tool head and will absorb the reaction forces from the tool's usage. According to NASA requirements on shovels the force exerted by the user will be roughly 75 lbs ("Human Performance Capabilities"). The first part analyzed was the fork sub assembly. The plot of the forces and stresses encountered is shown below in Figure 7. The legend on the far right hand shows a maximum stress encountered as 13.27 MPa which occured on the handle. The holes at the bottom of the fork that holds the ball bearings, there is a distribution of stress in reaction to that of the handle being shoved down. This stress comes from the T-rod's reaction and is the second most important point to look at with a maximum stress of 2.69 MPa. The yield compression stress found in MIL handbook 5 for Aluminum 6061 is 110 MPa (16 ksi) ("Metallic Materials and Elements for Aerospace Vehicles"). This means the stress experienced in the fork is below the yield stress, thus structurally sound.

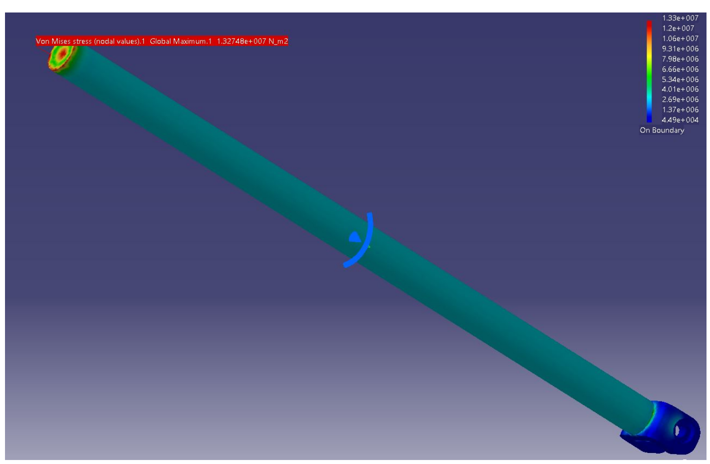

Figure 7: Fork Assembly FEA plot

The next part analyzed with CATIA’s FEA was the T-rod with the same force of 75 lbs at the bottom of the rod. This was shown upside down in the FEA plot below. The maximum value of stress found in the rod was closest to where the bearing is located because that section was considered the fixed point of the system. The stress was found to be 67.9 MPa. The assumption that the bearing location is fixed may be the reason why the stress appears at this location. However, with the previous yield compression stress found above (110 MPa) the internal stress will not yield the T-rod and is structurally stable.

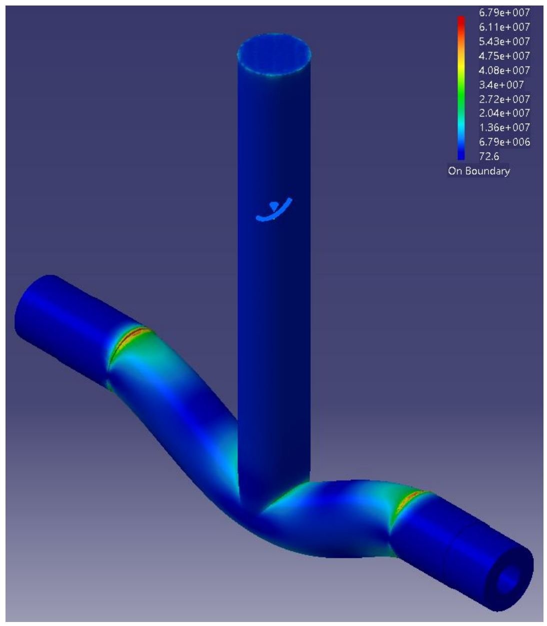

Figure 8: T-Rod FEA plot

8. Part Weight Analysis

Table 2: Weight Analysis

Item	Weight
4 Polymagnets	2 oz (0.5 oz each)
2 Ball bearing	1 oz (0.5 oz each)
2 M4 screws	0.32 oz
Scoop Head	4.5 oz
Aluminum Fork Head	8.19 oz
Aluminum Handle Rod and T Rod	8.42 oz
Aluminum Case	5.376 oz
Total Weight	29.81 (oz) (1.86 lbs)

C. Operations Plan

Before testing starts, the scoop tool head should be attached to the device. The device will then be operated manually; the operator will have one hand hold the device while the other hand maneuvers the pivot mechanism when necessary. The handle will have a diameter of 1.5 in so that astronauts can easily grip and apply force though their gloves. The device will be fully submerged, removed from the lunar dust simulant, and then cycled 10 times in the following manner:

1. Hold the device with the tool head's upwards.
2. The tool head will be at 0°(horizontal relative to handle).
3. Apply force on the tool head with the palm of the hand to torque it to 90°.
4. Apply force until a tactile feedback felt similar to gears locking indicates the tool head is locked at 90°.
5. Rotate the device to its upright position and use the device as trenching tool from a standing position.
6. Hold the device upside down.
7. Apply force on the tool head with the palm of the hand to torque it from 90° to 45°.
8. Apply force until a tactile feedback felt similar to gears locking indicating the tool head is locked at 45°.
9. Rotate the device to its upright position and use the device as scooper/digger from a standing position.
10. Store the scooped material.
11. Hold device upside down.
12. Apply force on the tool head with the palm of the hand to torque it from 45° to 0°.
13. Apply force until a tactile feedback felt similar to gears locking indicates the tool head is locked in a horizontal position at 0°.
14. Rotate the device to its upright position and use the device as scooper from a standing position.
15. Store the scooped material.

Similar testing will occur at ERAU prior to NBL testing; it will include both testing for dust-free durability and strength, and testing for sustainability under dust-coated conditions.

1. Project Outline

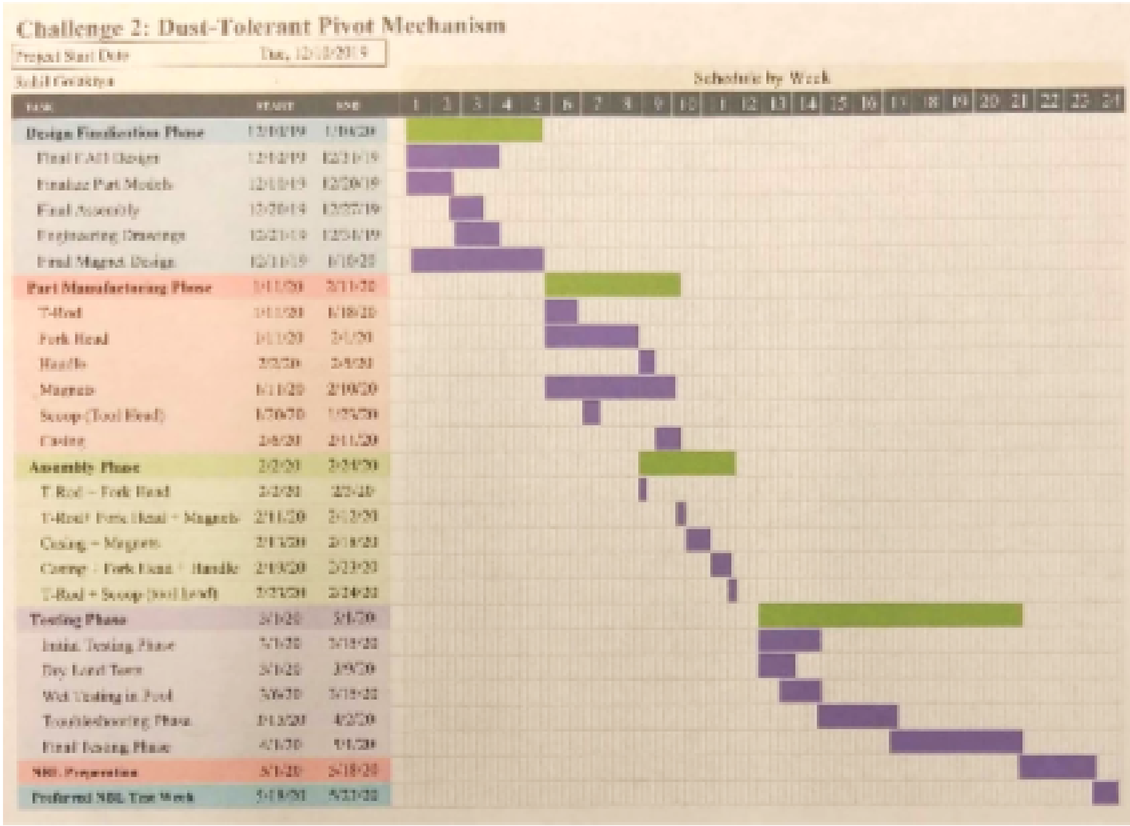

Figure 9: Gantt Chart for the production and testing of LSPD prior to NBL test week

Dust-free testing will occur to test the durability and strength of the pivot mechanism and the locking methods of both pivot and tool head attachment. Each degree the pivot can change to will be tested for durability and strength of the locking magnets by applying force to the handle and throughout the device. For 0°, a digging motion would be simulated to test force applied directly from the handle, and assure the locking magnets remain in place. The pivot would be tested next to assure it still worked after such pressure. A similar test will occur for 45°, and a simple scooping motion test will occur to test the pivot's strength in remaining locked in place. At 90°, a test similar to the latter will occur to test the pivot's locking strength. Once durability and strength are tested and assured, the tests aforementioned will be attempted again under dust-coated conditions. This will be for the sustainability of the already tested strength and durability under new conditions similar to those on the lunar surface.

D. Safety

When testing takes place, to assure safety in operating the device as well as the effectiveness of safety features, numerous tests will take place to assure the design operates as intended and to test the limits of that design. Testing will take place in a pool at ERAU.

Table 3: Situation Severity

Situation	Severity	Description	Solution
Fork design fails	High	As force is applied, an excess amount occurs and the fork fractures.	The fork design will be tested thoroughly to assure stability in holding. However, extreme forces will be required to cause this failure.
T-Rod fails	High	The T-Rod refused to turn or cannot be moved.	The T-Rod is mostly covered by the casing to prevent lunar dust from entering. Clean the T-Rod turning points.
Handle fails	Medium	Handle cannot be gripped or folds in.	The handle should be cleaned, otherwise the handle needs to be replaced.
Casing fails	Low	A sharp dent or a hole is torn in the casing surrounding the magnets.	The casing is designed to withstand substantial impact and the amount of force needed to cause such an issue will be tested.

1. Magnetic Interference

The issue of possible magnetic interference with both Earth's magnetic field and other items affected by magnetic fields will be minimized through the design of the magnets chosen for use. The polymagnets are designed with a very short-range magnetic field, so as to only interact within close proximity of another place of contact. Testing of these magnets will take place to assure this interaction remains within the designated range.

2. Edges and Openings

To completely clear sharp edges, the entire device will have rounded edges, and the tool head will be blunt to avoid such a danger. The hole in the casing for the fork design will also be less than an inch so that astronaut fingers are not at risk of entrapment. While the magnets are a pinch point, the casing will be designed to close off the astronauts from coming into contact with such pinch points.

E. Technical References

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II. Outreach Plan

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 elementary school that we will be pairing with is Turie T. Small Elementary, which is located in Daytona Beach, Florida. Specifically, we will be working with their fifth grade students. The goal of the outreach to the fifth grade students at Turie T. Small Elementary 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 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 experiment amongst fourth and fifth grade teams at Turie T. Small Elementary School which will require them to use basic materials to craft a basic lava lamp in a water bottle. The goal will be to use the materials to make a basic lava lamp (exact procedures and materials for this competition will be listed at the end of this section). The educational goal of such an experiment will be to educate students on the basic principles of the four states of matter, such that they will have a better understanding of the universe around them, while also getting to have a hands-on arts and crafts activity. While learning about the different types of matter, the students will also learn more about how said matter interacts to form everything we see (and cannot see). In addition, the students will get a brief overview of how samples of matter can be analyzed, and what the analysis of it can tell us about its properties - thus tying into the Micro-g NExT Lunar Sample Collection challenge, as the astronauts will be needing to analyze the samples they collect to learn more about them. In addition, this activity ties into the Florida 5th grade science curriculum standards of "explore what moons, asteroids, and comets are," as we will also briefly discuss the constituency of these astronomical bodies. 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 the types of matter and how they interact.

2. *Explore:* The students will identify and develop knowledge of the various properties of matter through their crafting of the lava lamp.
3. *Explain:* The students will build their lava lamps and will be able to successfully demonstrate their understanding of the properties of matter by discussing their designs.
4. *Elaborate:* The students will learn more about sample analysis and the composition of moons, asteroids, and comets, and how certain tools are used to collect matter.
5. *Evaluate:* The students will demonstrate their understanding of matter and sample collection by being able to discuss what they have learned through some basic closing questions

The required materials and procedures for this project are listed below. All materials will be obtained using the club's budget, which is detailed in Section III Part F.

a) *Materials*

Water, vegetable oil, food coloring, alka seltzer tablets

b) *Procedures*

(1) Use the materials provided to design and build a basic lava lamp
(2) Discuss the properties of the lava lamps.
(3) Discuss the design compared to the end result.

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 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 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 Club 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: Ms. Zaneta S. Whipple, 5th Grade Teacher
zswhippl@volusia.k12.fl.us

Communication Logs:

MJ
Mosteller, Zachary J.
Tue 10/29/2019 3:25 PM
zswhippl@volusia.k12.fl.us

Good afternoon,

My name is Zachary Mosteller and I am the Outreach Officer for the Embry-Riddle Microgravity club. It was brought to my attention that our club has worked with you previously in doing an educational event at Turie T. Small Elementary, and I was curious if you would be open to hosting us again for your students. This event would be similar in nature to what we did last time, and we would be aiming to have it either later this semester or early next semester, if possible.

I would be happy to provide you with more detailed information on our ideas if you would like to hear them.

I look forward to hearing back from you soon, and thank you for your time and consideration.

Sincerely,

Zachary Mosteller

Experimental Rocket Propulsion Lab | Vice President
Embry-Riddle Eagle Scout Association | President
Phi Beta Lambda | President
Microgravity Club | Outreach
American Society of Mechanical Engineers | Outreach
College of Business | Student Assistant
PEER Mentor
Business Marketing Undergraduate
Embry-Riddle Aeronautical University
Daytona Beach Campus
(704) 691-4326

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 27, 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 Pivot Mechanism" 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: sathya@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 27, 2019

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

RE: "Statement of Supervising Faculty" for the 2019-2020 NASA Student Micro-G NExT Design Challenge."

Dear Micro-G NExT Selection Board:

As a faculty advisor for the experiment entitled "Dust-Tolerant Pivot Mechanism" proposed by a diverse team of undergraduate students from Embry-Riddle Aeronautical University, Daytona Beach Campus, I concur with the concepts and methods by which this project will be conducted. I will ensure that all reports and deadlines are completed by the student team members in a timely manner. I 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,

Sathya Gangadharan Ph.D., P.E., C.Mfg.E.
Professor, Mechanical Engineering
Embry-Riddle Aeronautical University
Daytona Beach, Florida 32114
Tel: (386) 226-7005
Fax: (386) 226-6011
Email: sathya@erau.edu

embryriddle.edu

E. Statement of Rights of Use

As a team member for a proposal entitled "Lunar Sampling Pivot Device" 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 "Lunar Sampling Pivot Device" 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

Rahil Golakiya – Team Lead

Sam Buchanan – Member

Poorendra Ramlall – Member

Chryseis Smith – 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				
Polymagnet	Link	8	$20	$160
Ball Bearing	Link	4	$1.64	$6.56
Tool Head	Link	2	$4.79	$9.58
Al Handle	Link	2	$28.50	$57
Al Sheets (case)	Link	2	$100	$200
Al T-Rod	Link	2	$50	$100
M4 Screw	Link	4	$0.39	$1.56
Manufacturing Costs				
Fork Head	Link	2	$85.21	$170.42
Outreach Materials				
				$100
Travel				
Gas				$600.00
Hotel				$3,500
Food		84 meals	$15	$1,260
Total				**$6,165.12**

G. Parental Consent Forms

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

IV. Appendix I

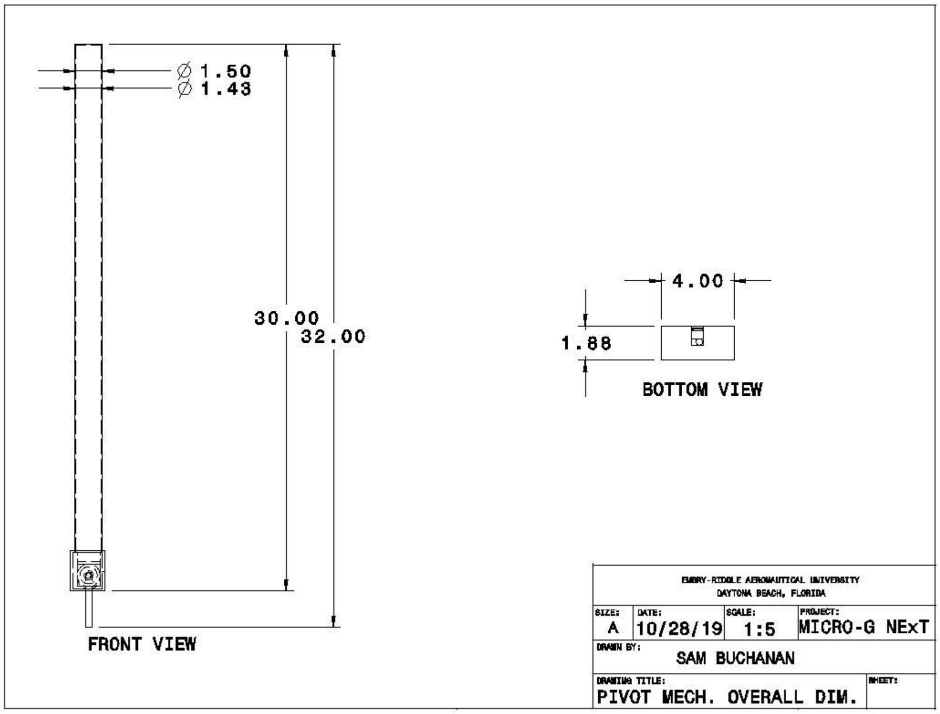

Figure 10: Overall Dimensions of the Lunar Sampling Pivot Device

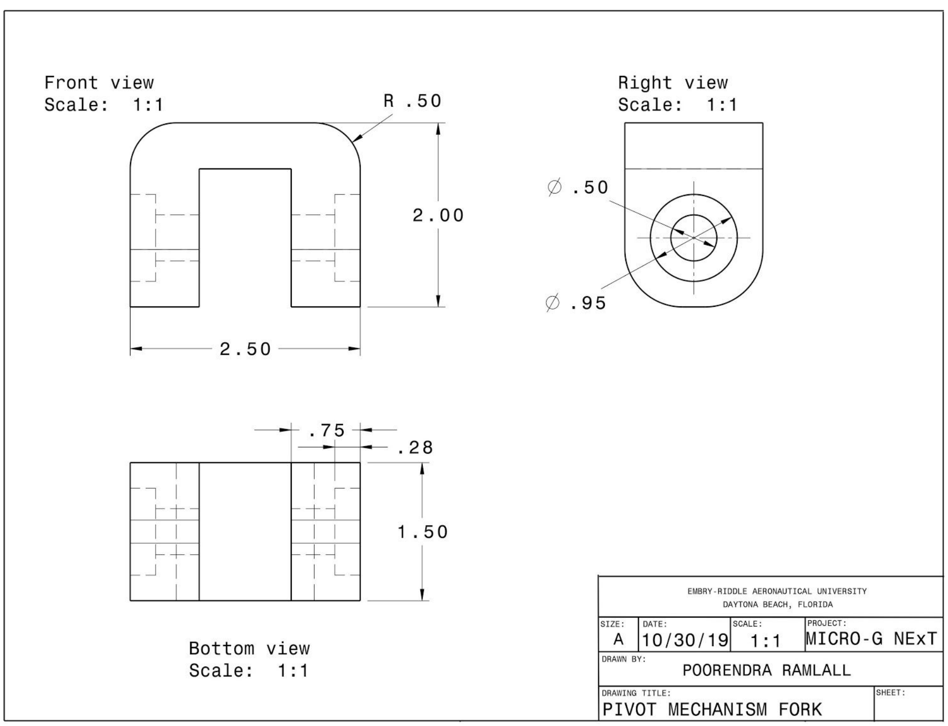

Figure 11: Overall Fork Head Dimensions

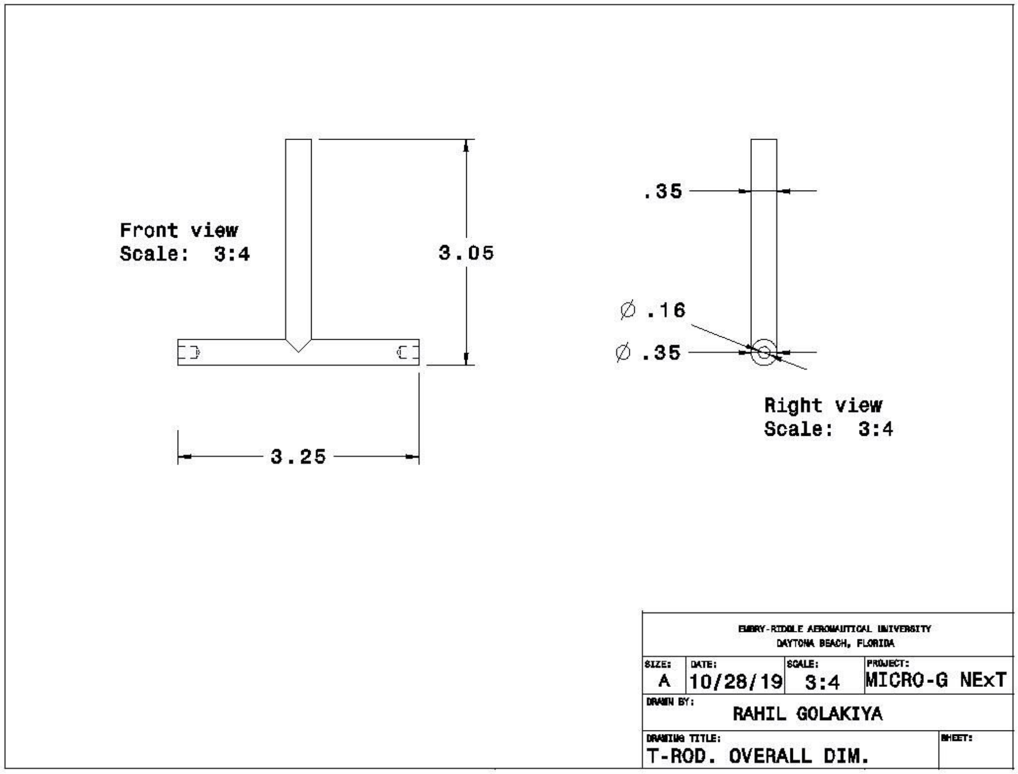

Figure 12: Overall T-Rod Dimensions

V. Appendix II

Typical Magnetic Properties of Sintered NdFeB Materials

Grade	Remanence		Coercivity				Energy Density		Operating	Temperature Coefficient	
	B_r		H_{cJ}		H_{cB}		$(BH)_{max}$		T_wMax	TK(Br)	Tk(Hcj)
	T	kGs	kA/m	kOe	kA/m	kOe	kJ/m³	MGOe	°C	%/℃	%/℃
N35	1.17-1.22	11.7-12.2	≥955	≥12	≥876	≥11	263-287	33-36	80	-0.11	-0.6
N38	1.22-1.26	12.2-12.6	≥955	≥12	≥876	≥11	287-310	36-39	80	-0.11	-0.6
N40	1.25-1.29	12.5-12.9	≥955	≥12	≥876	≥11	302-326	38-41	80	-0.11	-0.6
N42	1.28-1.32	12.8-13.2	≥955	≥12	≥876	≥11	318-342	40-43	80	-0.11	-0.6
N45	1.33-1.37	13.3-13.7	≥955	≥12	≥876	≥11	342-366	43-46	80	-0.11	-0.6
N48	1.37-1.42	13.7-14.2	≥955	≥12	≥876	≥11	366-390	46-49	80	-0.11	-0.6
N50	1.39-1.44	13.9-14.4	≥955	≥12	≥836	≥10.5	374-406	47-51	80	-0.11	-0.6
N52	1.42-1.47	14.2-14.7	≥955	≥12	≥836	≥10.5	390-422	49-53	80	-0.11	-0.6
N35M	1.17-1.22	11.7-12.2	≥1114	≥14	≥876	≥11	263-287	33-36	100	-0.1	-0.6
N38M	1.22-1.26	12.2-12.6	≥1114	≥14	≥915	≥11.5	287-310	36-39	100	-0.1	-0.6
N40M	1.25-1.29	12.5-12.9	≥1114	≥14	≥939	≥11.8	302-326	38-41	100	-0.1	-0.6
N42M	1.28-1.32	12.8-13.2	≥1114	≥14	≥963	≥12.1	318-342	40-43	100	-0.1	-0.6
N45M	1.32-1.36	13.2-13.6	≥1114	≥14	≥987	≥12.4	342-366	43-46	100	-0.1	-0.6
N48M	1.37-1.42	13.7-14.2	≥1114	≥14	≥1019	≥12.8	358-390	45-49	100	-0.1	-0.6
N50M	1.39-1.45	13.9-14.5	≥1114	≥14	≥1035	≥13	374-406	47-51	100	-0.1	-0.6
N33H	1.13-1.17	11.3-11.7	≥1353	≥17	≥860	≥10.8	247-271	31-34	120	-0.1	-0.56
N35H	1.17-1.22	11.7-12.2	≥1353	≥17	≥884	≥11.1	263-287	33-36	120	-0.1	-0.56
N38H	1.22-1.26	12.2-12.6	≥1353	≥17	≥923	≥11.6	287-310	36-39	120	-0.1	-0.56
N40H	1.25-1.29	12.5-12.9	≥1353	≥17	≥947	≥11.9	302-326	38-41	120	-0.1	-0.56
N42H	1.28-1.32	12.8-13.2	≥1353	≥17	≥971	≥12.2	318-342	40-43	120	-0.1	-0.56
N45H	1.32-1.36	13.2-13.6	≥1353	≥17	≥1003	≥12.6	342-366	43-46	120	-0.1	-0.56
N48H	1.37-1.42	13.7-14.2	≥1353	≥17	≥1035	≥13	358-390	45-49	120	-0.1	-0.56
N50H	1.39-1.44	13.9-14.4	≥1274	≥16	≥1035	≥13	374-406	47-51	110	-0.1	-0.56
N30SH	1.08-1.13	10.8-11.3	≥1592	≥20	≥820	≥10.3	223-247	28-31	150	-0.095	-0.56
N33SH	1.13-1.17	11.3-11.7	≥1592	≥20	≥860	≥10.8	247-271	31-34	150	-0.095	-0.56
N35SH	1.17-1.22	11.7-12.2	≥1592	≥20	≥884	≥11.1	263-287	33-36	150	-0.095	-0.56
N38SH	1.22-1.26	12.2-12.6	≥1592	≥20	≥923	≥11.6	287-310	36-39	150	-0.095	-0.56
N40SH	1.25-1.29	12.5-12.9	≥1592	≥20	≥947	≥11.9	302-326	38-41	150	-0.095	-0.56
N42SH	1.28-1.32	12.8-13.2	≥1592	≥20	≥971	≥12.2	318-342	40-43	150	-0.095	-0.56
N44SH	1.31-1.35	13.1-13.5	≥1592	≥20	≥995	≥12.5	334-358	42-45	150	-0.095	-0.56
N45SH	1.32-1.36	13.2-13.6	≥1592	≥20	≥1003	≥12.6	342-366	43-46	150	-0.095	-0.56
N48SH	1.37-1.42	13.7-14.2	≥1512	≥19	≥1035	≥13	358-390	45-49	150	-0.095	-0.56
N30UH	1.08-1.14	10.8-11.4	≥1990	≥25	≥820	≥10.3	223-247	28-31	180	-0.09	-0.56
N33UH	1.13-1.19	11.3-11.9	≥1990	≥25	≥860	≥10.8	247-271	31-34	180	-0.09	-0.56
N35UH	1.17-1.22	11.7-12.2	≥1990	≥25	≥884	≥11.1	263-287	33-36	180	-0.09	-0.56
N38UH	1.22-1.26	12.2-12.6	≥1990	≥25	≥923	≥11.6	287-310	36-39	180	-0.09	-0.56
N40UH	1.25-1.31	12.5-13.1	≥1990	≥25	≥947	≥11.9	302-326	38-41	180	-0.09	-0.56
N42UH	1.28-1.34	12.8-13.4	≥1990	≥25	≥971	≥12.2	310-342	39-43	180	-0.09	-0.56
N45UH	1.32-1.37	13.2-13.7	≥1910	≥24	≥1003	≥12.6	342-366	43-46	170	-0.09	-0.56
N30EH	1.08-1.13	10.8-11.3	≥2388	≥30	≥820	≥10.3	223-247	28-31	200	-0.085	-0.56
N33EH	1.13-1.17	11.3-11.7	≥2388	≥30	≥860	≥10.8	247-271	31-34	200	-0.085	-0.56
N35EH	1.17-1.22	11.7-12.2	≥2388	≥30	≥884	≥11.1	263-287	33-36	200	-0.085	-0.56
N38EH	1.21-1.26	12.1-12.6	≥2388	≥30	≥915	≥11.5	295-326	37-41	200	-0.085	-0.56
N40EH	1.25-1.31	12.5-13.1	≥2388	≥30	≥947	≥11.9	302-326	38-41	200	-0.085	-0.56
N30AH	1.07-1.13	10.7-11.3	≥2706	≥34	≥812	≥10.2	215-247	27-31	230	-0.085	-0.56
N33AH	1.11-1.17	11.1-11.7	≥2706	≥34	≥844	≥10.6	239-271	30-34	230	-0.085	-0.56