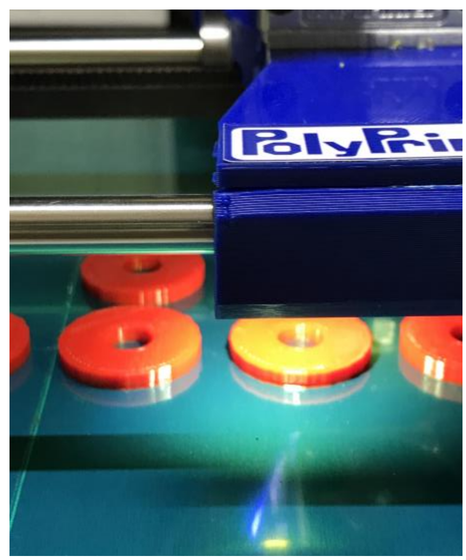
Mars Mission Specialist: Payload Design Challenge

Teacher Handbook



This handbook contains resources to help teachers implement the design activities described in the following article:

Burton, Bill, et al., "Mars Mission Specialist." *Science and Children*, vol. 55, no. 7, March 2018.

Contents

Teacher Tips

General

- The containers of small materials will likely spill at some point. It's helpful to have a cleanup plan.
- Print times will vary based on number of payloads, 3D printer type, number of 3D printers available and other variables. Plan ahead for extended printing times and possible clogs or printer errors.
- Before beginning to use Tinkercad, students will need to have individual accounts set up (see next page).
- Consider introducing Tinkercad with a beginner design project so students can become familiar with the design platform.

Design and Printing

- Avoid printing payloads using the printer's "fill" setting. To avoid payloads that are too heavy, use draft or a partial fill setting instead.
- Different 3D printers may print payloads differently.
- Print sample payloads and check their masses before printing students projects.
- PLA plastic is more dense that ABS plastic. This will impact final payload mass.
- Some designs with "overhang" design elements may need "support structures" when printing. 3D printers without this printing feature should avoid printing payloads with "overhang" elements.
- Printed payloads may need to be cleaned of small plastic threads. Tools such as wax carver instruments, dental cleaning tools and/or electric drills work well to remove these.
- Have a few 'example' payloads on hand just in case any student designs are flawed.

Sourcing Materials

Pitsco

www.pitsco.com

- Mars Mission Specialist: Payload Design Challenge classroom sets
- Rocketry Sets
- Estes Bulk Rocket Engines

Nasco

www.enasco.com

- Estes Bulk Rocket Engines
- Plastic Forensic Jars

For a la carte materials:
Amazon: www.amazon.com
Perler: www.perler.com
General Craft Stores

Creating Class Tinkercad Accounts

- Create your own Tinkercad Account
- Click on the **Teach** tab at the top
- On the Teach page, click **Create A New Code**. This is the code students will use to become approved by the teacher.
- Students will then create their own account. Consider using a school login name or prescribed identifier for login names. Common names may have to use middle names as well, i.e. jsmith123 may need to be jrsmith123 or jimmysmith123
- If students are under 13, a parent/adult email will be required to create the account.
- Consider requiring students to use school assigned passwords or a common class password
- Once students have created their account they will have the ability to "**Get Approved Now**" by adding the **class code** into the box. Students will then be automatically added to the **Moderate Kids** section on the teacher profile.

Human-Centered Design Thinking Resources

K12 Lab Network

- K12 Lab Network at the d.school
- K12 Lab Network Curriculum Wiki
- K12 Lab Network Resource Guide

Teaching Innovation/Innovative Thinking

- Where Innovation Comes From
- Get More Innovative by Rethinking the Way You Think
- Why Do People Think You Can't Teach CREATIVITY?
- Learning to Think Outside the Box
- An article about teaching innovation through design and making

Developing Confidence, Creativity, Resilience

- Students Can Learn From Their Mistakes If We Let Them
- The Gift That Keeps On Giving: Sparking Student Curiosity
- How to Build Creative Confidence in Kids
- Learning by Doing ... and Grappling
- What Teachers Learn by Taking Risks

Design Thinking in Education

- Design Thinking in Education: Empathy, Challenge, Discovery, and Sharing
- Design Thinking, Making, and Learning From the Heart
- RED Lab at Stanford - Research in Education + Design
- Design Thinking Research

Empathy, Trade-Offs, and Mars Colony Food Choices

Part I: What are trade-offs? How can we use empathy to maximize quality of life?

Students gather with a notebook or paper/clipboard.

If you were in charge of choosing all the food for yourself this weekend, what would you pick? Jot down four food items.

Now imagine you're choosing food for your entire family for this weekend, what would you pick? Draw a line and jot down four food items. What did you consider when designing this menu? How does this change your food choices from when you were just thinking about yourself? [Students consider nutrition, what each family member likes/dislikes, variety, etc.]

What if you invite your friend over and she's gluten free (or vegetarian, allergic to nuts, etc.)? What changes would you make? Jot down a new list of four foods.

Ask students to reflect on this exercise. Why didn't they stick with the original four items? What makes the second or third menu better? Are you still happy with the menu? (Maybe not as happy as you were at first, but you're still satisfied with the selection)

This conversation should lead into a discussion of the following terms (on a chart).

Define vocabulary:

- Empathy – understanding how other people feel
- Trade-off – sacrificing one option for another option that is better in some way
- Compromise – an agreement that is reached when each side gives up something
- Quality of Life – health, comfort, and happiness for a group of people
- Nutrition – food that is necessary for human growth and health
- Sacrifice – to give up something to achieve a goal

Part II: Consider the project question – What food choices will you make when designing the journey to Mars?

What are the pros and cons of each food source (plants, insects, chickens)?
[Make a T-chart on the board.]

What trade-offs will you need to make? What are the quality of life considerations? How can you think about this topic from many different people's perspectives?

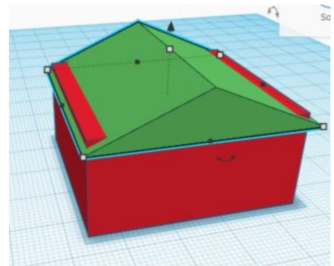
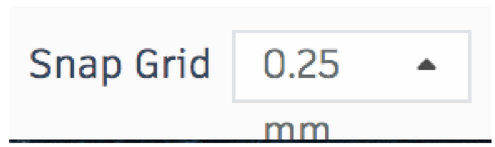
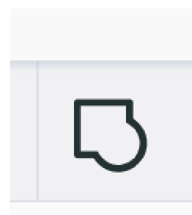
Part III: Writing

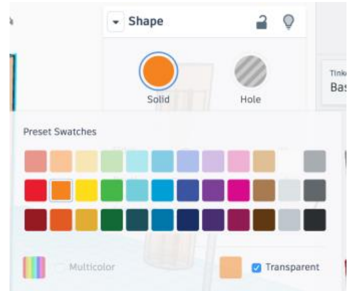
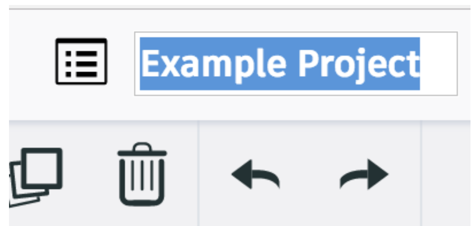
Students write a persuasive paragraph about the choices they made. They can use vague terms ("some insects and some chickens," "mostly plants, but a few chickens"). They give at least three supporting reasons for why their combination of food sources is ideal and takes into account many different factors.

Food Sources for the Mars Colony

	Recruit Still working to meet expectations	**Officer** Met expectations for third grade writing	**Commander** Went above expectations
Paragraph Structure	The paragraph is not focused on food sources for the Mars colonists. OR The paragraph does not have three reasons for the food selections.	The paragraph is focused on the food sources for the Mars colonists. There are three supporting reasons for the food selections. There is a closing sentence.	The paragraph is focused on the food sources for the Mars colonists. There are three supporting reasons, and you wrote 2-3 sentences to explain each reason. There is a closing sentence that is worded differently than the topic sentence.
Supporting Facts	You did not include any facts to support your food choices or the information was not accurate.	You included a few (1-3) accurate and realistic facts to support your food choices.	You included many (4 or more) accurate and realistic facts to support your food choices.
Empathy and Trade-Offs	The food selections do not reflect the needs and preferences of Mars colonists.	The food selections reflect the needs and preferences of Mars colonists.	The food selections reflect the needs and preferences of Mars colonists. You explained why a different combination of food sources would not be ideal for the colonists.
Grammar, Spelling, and Punctuation	There are **many** mistakes in: • Spelling • Complete sentences • Apostrophes • Capitalization	There are **some** mistakes in: • Spelling • Complete sentences • Apostrophes • Capitalization	There are **very few** mistakes in: • Spelling • Complete sentences • Apostrophes • Capitalization

Tinkercad Design Reminders

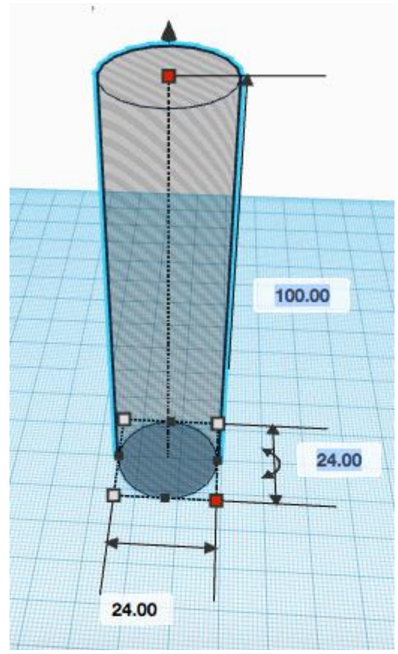
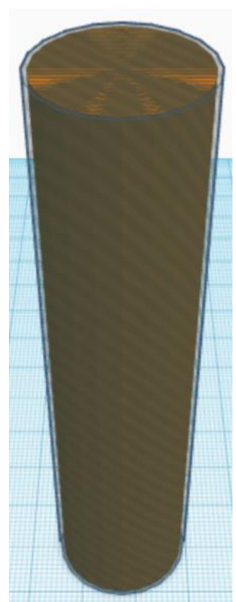
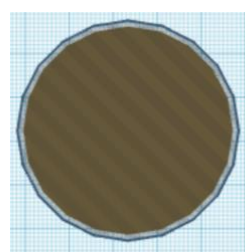
Bury shapes together	
For fine adjustments, change the snap grid to a smaller number	
Group your shapes to make a new shape	
Change your view to inspect new shapes from every angle **(DO EVERY TIME)**	
If you make a mistake, undo it right away	

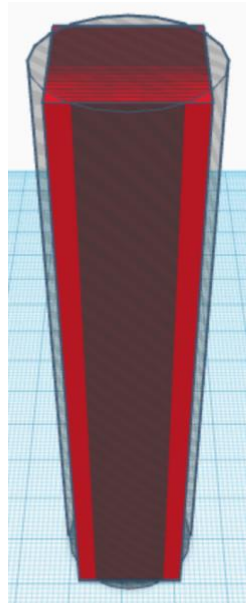
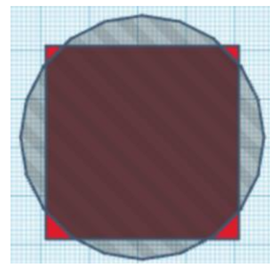
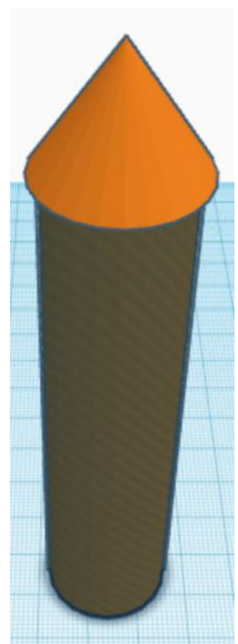
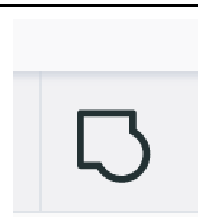
Change the Colors Or Make a Hole	
Rename the project	
Make sure the design is on the workplane Not above or below	

Making and Using the **Sizing Cylinder**

Purpose: The Sizing Cylinder is the first step in the Tinkercad portion of the Payload Design Challenge. The Sizing Cylinder serves as a student tool during the design process that does NOT become part of the final design. Essentially, the Sizing Cylinder is a digital representation of a rocket body tube. Student payload designs should fit within the Sizing Cylinder. If any portion of the student design protrudes from the Sizing Cylinder, the final 3D printed payload may not fit in the rocket. When not in use, the Sizing Cylinder can be set off to the side of the Tinkercad workplane.

Making and Using the **Sizing Cylinder**

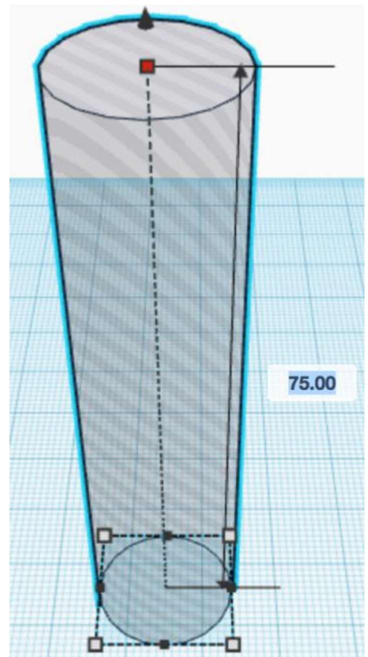
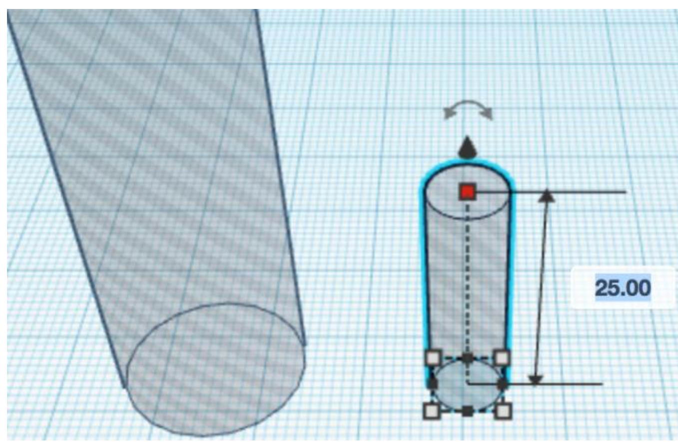
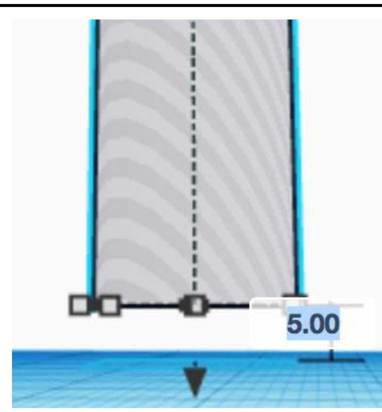
Create a **Cylinder** **Hole** that is 100mm tall and 24mm x 24mm at the base	
Payload Sizing Correct	 

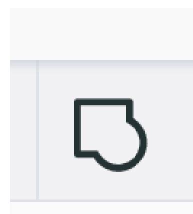
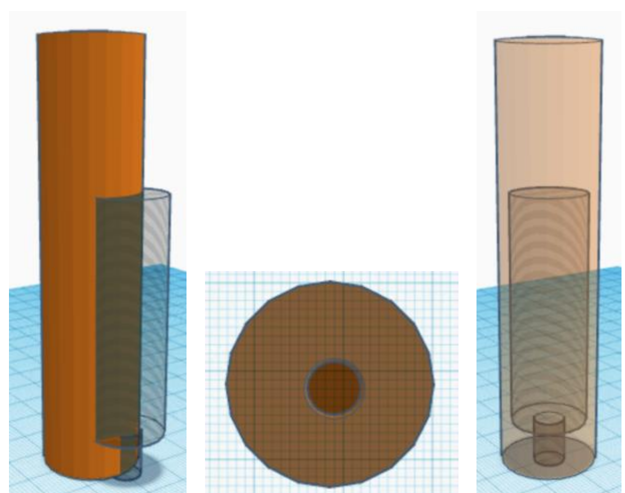
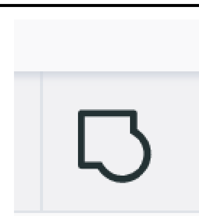
Payload Sizing Incorrect	 
Payload Sizing With Nosecone Correct	
Group your shapes to make a new shape	

Making Payload **Material Containment Holes**

Purpose: The Material Containment Holes are internal chambers designed to contain the simulated food sources and their support materials. Although these holes don't have specific design parameters, the guide below offers one suggested method. Younger students may need explicit instruction and directions while older or more advanced students may be challenged to design their own containment holes.

Making Payload **<u>Material Containment Holes</u>**

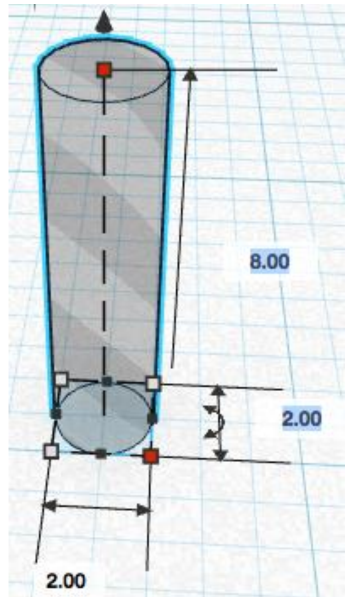
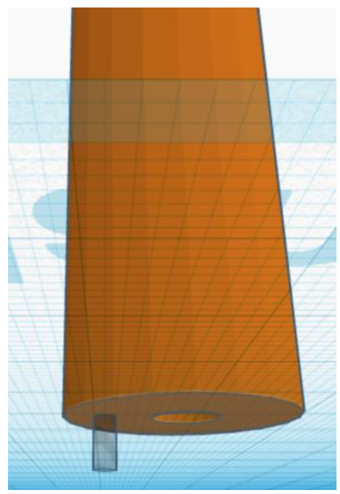
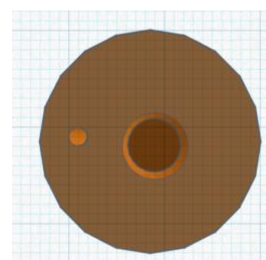
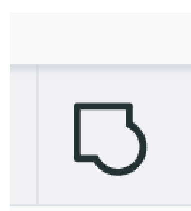
Create a **Cylinder <u>Hole</u>** that is 75mm tall and 18mm x 18mm at the base.	
Create a second **Cylinder <u>Hole</u>** that is 25mm tall and 7mm x 7mm at the base.	
Use the cone to raise the large hole 5mm.	

Position the large cylinder on top of smaller cylinder	
Group the cylinders to make a single hole	 
Drag the hole into the payload and check the placement	
Group your shapes to make a new shape	

Making Payload **Screweye Hole**

Purpose: The Screweye Hole is the final addition to the payload design. After having experience designing in Tinkercad during the Payload Design Challenge, the Screweye Hole is a simple process for students. Although the height of this hole can be more than the example, the base measurement of 2mm x 2mm should be exact. This hole will be where the threads of the screweye screw into the printed plastic. The parachute is attached to the screweye. Improperly sized Screweye Holes may result in a weak attachment between parachute and payload.

Making Payload **<u>Screweye Hole</u>**

Create a **Cylinder <u>hole</u>** that is 8mm tall and 2mm x 2mm at the base	
Drag the Screweye hole into the payload Check the placement	 
Group your shapes to make a new shape	

Payload Contents Planning and Evaluation

	Planned or Estimated	Actual	Is Actual Less, Equal or More?
Number of Plant Units			Less Equal More
Number of Insect Units			Less Equal More
Number of Chicken Units			Less Equal More
Total Number of Crop Units			Less Equal More
Mass of Empty Payload			Less Equal More
Mass of Payload Contents			Less Equal More
Mass of Full Payload			Less Equal More

Describe any differences between your plans and your final product:

Pre-Print Evaluation

Does my design:	Yes	No
Meet the size requirements?		
Fit within the Testing Cylinder?		
Touch the Workplane?		
Include a Screw Eye Hole?		
Include an identifiable feature?		
Avoid overhangs?		

Pre-Launch Evaluation

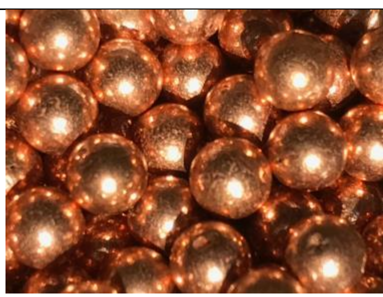
Does my payload:	Yes	No
Fit into the rocket?		
Meet the mass requirements?		
Hold all the payload contents?		
Attach to the parachute?		
Seal properly?		

Mars Mission Debrief Discussion Questions

- What are some of the aspects that you liked about the Payload Design Challenge?
- Can anyone name a challenge or a setback that you had to overcome?
- Were there any ideas that you shared with someone else or that someone shared with you?
- What was the highest number of food units included in a payload? And the lowest?
- How did empathy play a role in your design process?
- Can anyone share an example of an accomplishment someone else made or a something they liked about someone else's project?
- If you were to do this project again, what would you do differently? Or what would you keep the same?

Materials Reference Sheet

Plant Seed Units	Insect Units	Chicken Units
Color: Green **Material:** Plastic **Mass:** .06g **Size:** 5x5mm	**Color:** Orange **Material:** Plastic **Mass:** .06g **Size:** 5x5mm	**Color:** Yellow **Material:** Plastic **Mass:** .06g **Size:** 5x5mm
		

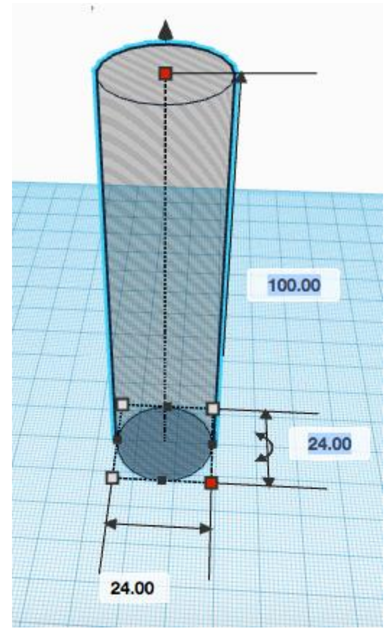
Water Units	Food/Nutrient Units	Oxygen Units	Technology/Building Units
Color: Copper **Material:** Metal **Mass:** .34g **Size:** 4.5mm	**Color:** White **Material:** Plastic **Mass:** .20g **Size:** 6mm	**Color:** Red **Material:** Plastic **Mass:** .12g **Size:** 6mm	**Color:** Grey **Material:** Plastic **Mass:** .06g **Size:** 5x5mm
			

Materials Reference Sheet

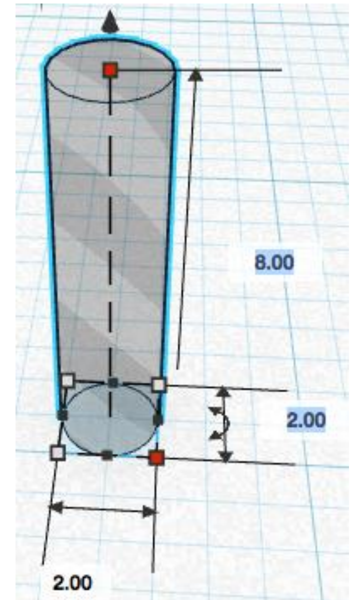
	Needs per Food Unit Type			
Food Type	**Water** .34g each	**Food/Nutrient** .20g each	**Oxygen** .12g each	**Tech/Building** .06g each
Plant	3	1	0	3
Insect	1	2	2	1
Chicken	4	5	4	4

**For every Plant Unit taken to Mars, one Oxygen Unit may be eliminated.

**For every Plant Unit taken to Mars, one Food Unit may be eliminated from Insect Unit needs.

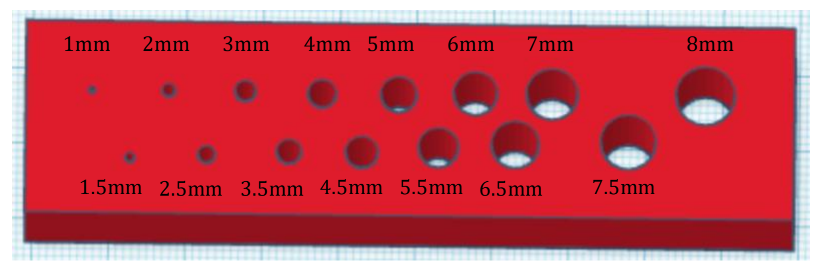


Sizing Cylinder



Screw Eye Hole Example

	Payload Constraints (full)	
Parameter	**Standard Payload**	**Payload with Nosecone**
Mass	28g	35g
Height	100mm	120mm
Diameter	24mm	
Feature 1	Screw Eye Hole	
Feature 2	Identifying Feature	



Sizing Block