
[Team BFG]

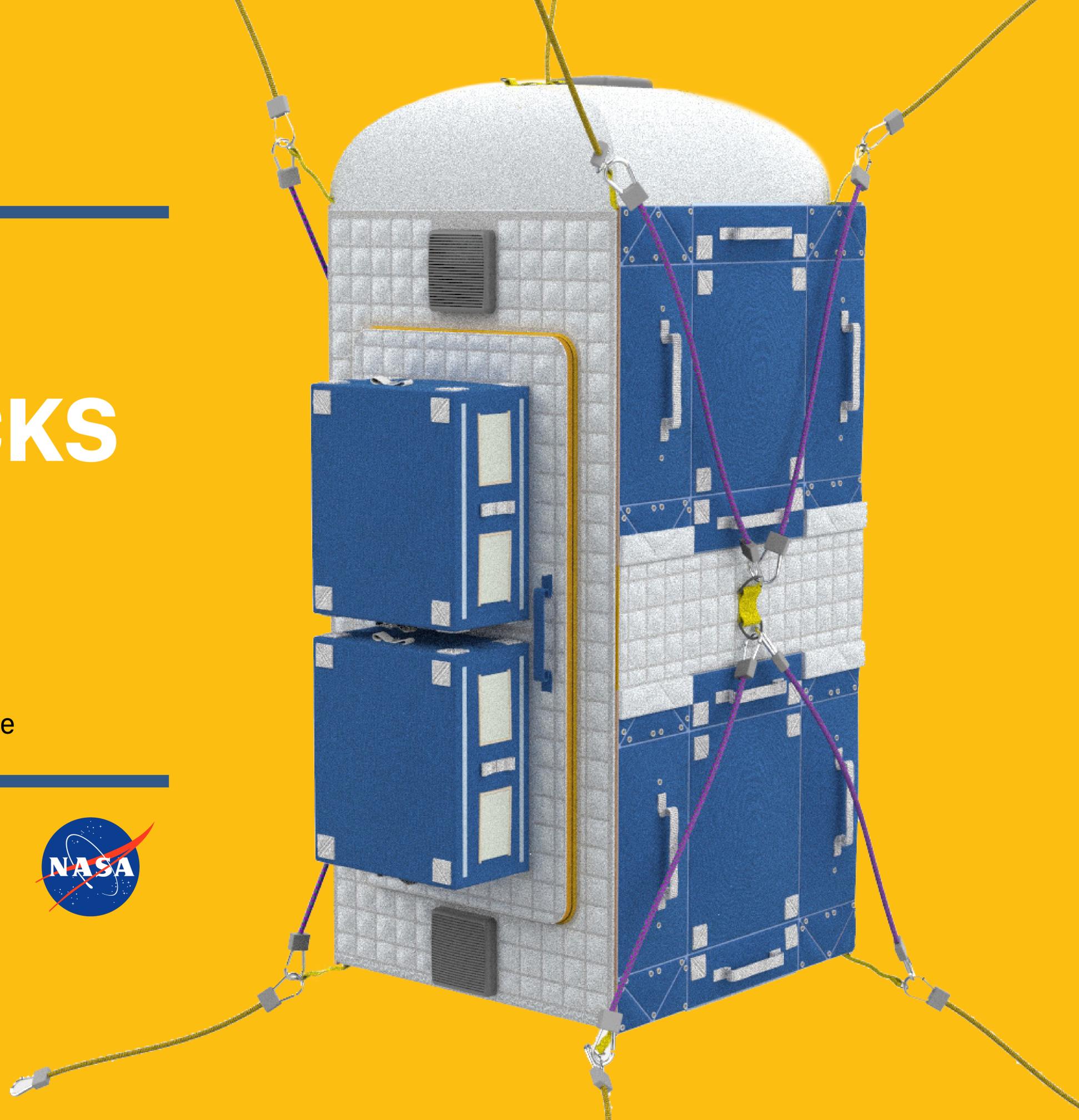
BED FOR GOLDDILOCKS

A stowable sleeping
compartment kit for
astronauts.

Ellen Ren, Jihun Kang, Andrew Lee

Pratt

BFG



Team BFG

TEAM BFG stands for Bed for Goldilocks, which is also the name for our compartment.
like the Goldilocks story, BFG is a bed “just right” for the astronauts.



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Orion mockup with MACES suited personnel

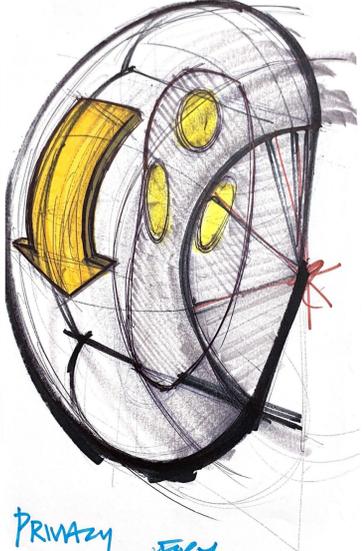
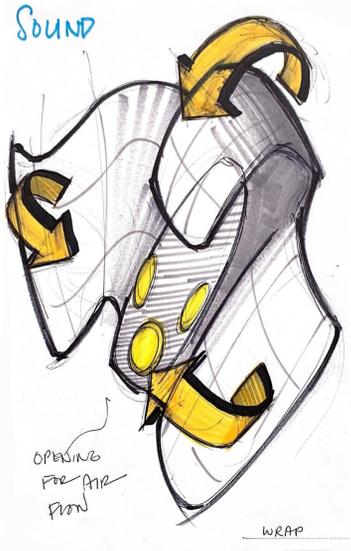
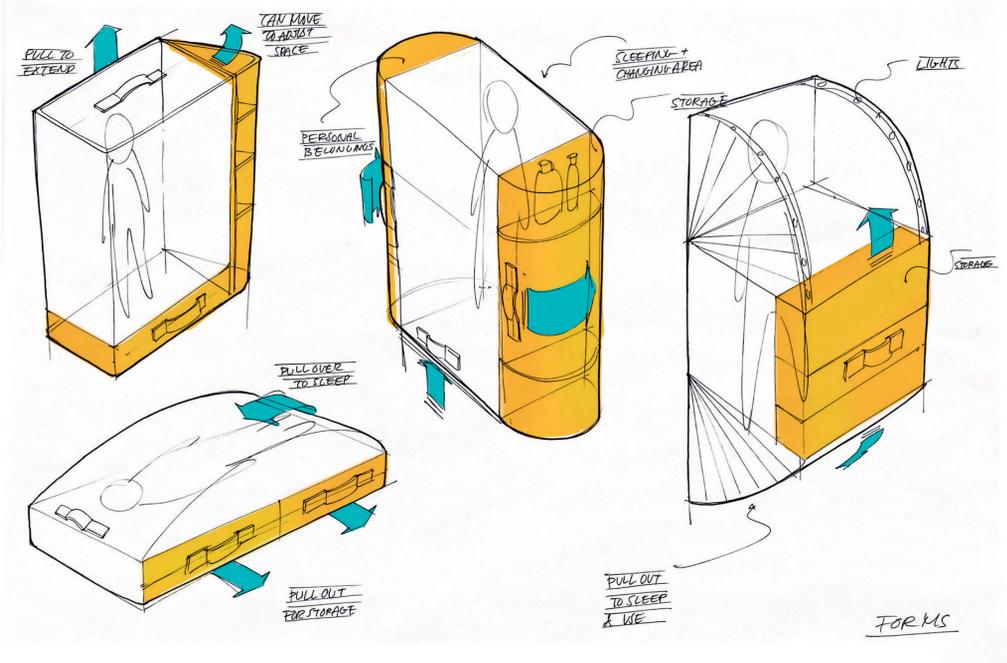
PROBLEM

Unlike crew onboard the ISS, future spacecrafts of limited capacity cannot provide them with dedicated sleeping compartments. Without privacy, astronauts do not have a place to tend their personal needs. Microgravity environments cause discomfort and improper ventilation, putting astronauts at risk of suffocation from stagnant carbon dioxide. Heavy materials burden costs and potency of spacecrafts. Regardless the duration of spaceflights, these factors prove to reduce astronauts' efficiency and productivity in outer space.

OBJECTIVES

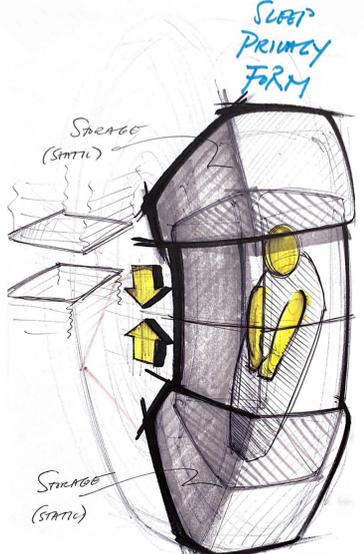
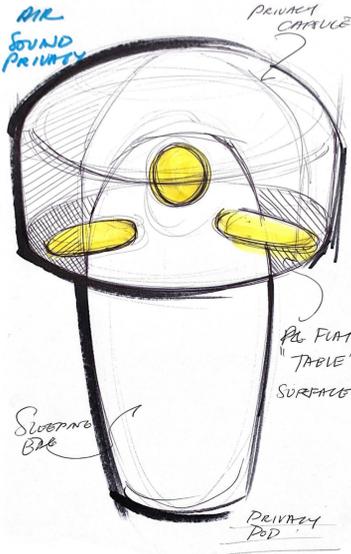
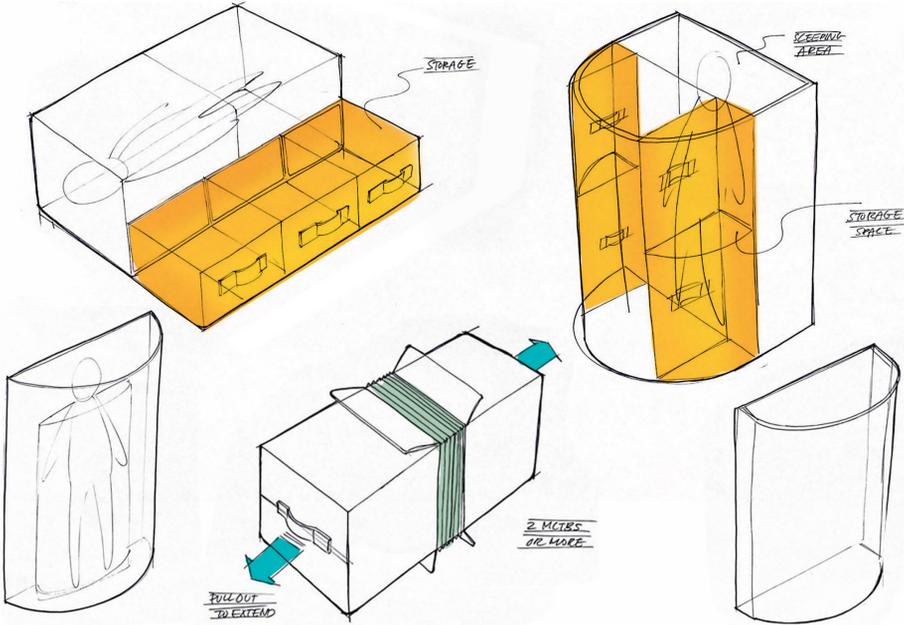
To design and test a sleeping compartment for future spacecraft crew members, which make use of Acoustic Multipurpose Cargo Transfer Bags (AMCTBs). The sleeping compartments will satisfy the allotted volume of 53 cubic ft. with a work space, designated storage for personal effects, and ample room to change their clothes. The air in the sleeping compartments will be ventilated to prevent suffocation from stagnant carbon dioxide due to microgravity.

FORM IDEATION SKETCHES

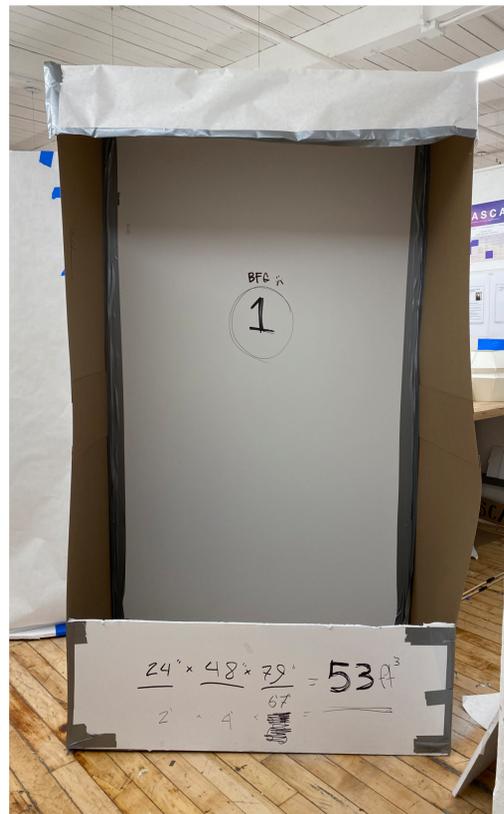
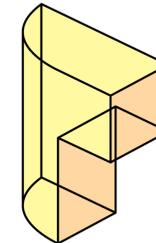
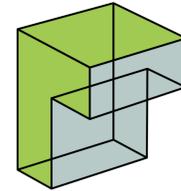
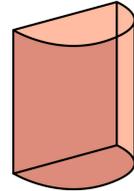
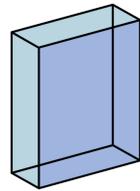


We drew some form sketches for the sleeping compartment to start our ideation process.

After sketching these, we realized that we needed to figure out how 53 cubic feet felt first.

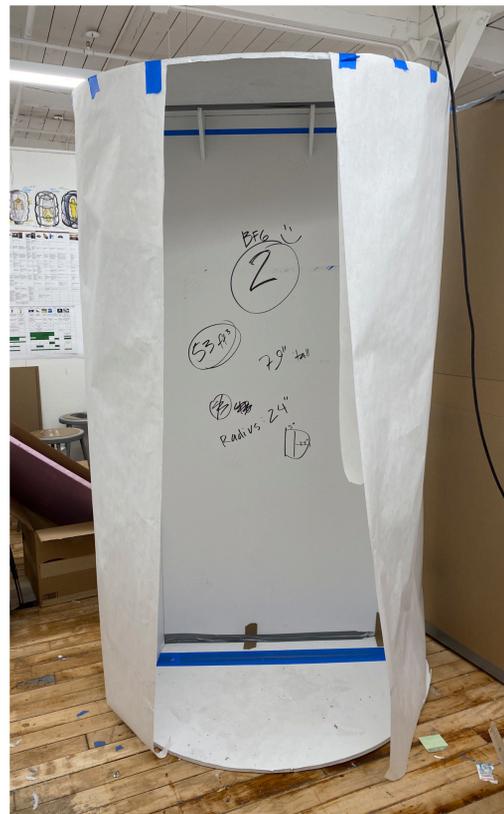


VOLUME STUDY



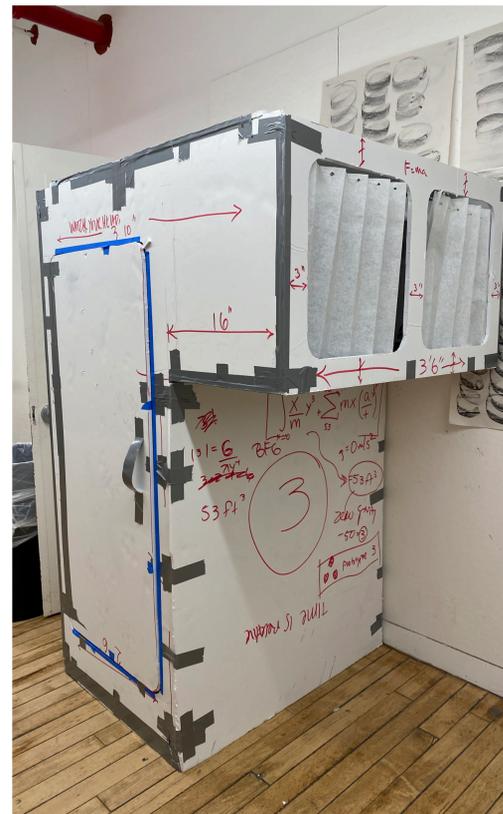
24 in. x 48 in. x 79 in. Rectangular Area=
79 in. x 5.3 in. x 48 in.

Cylindrical Area=
(24² in. x pi)



30 in. x 48 in. x 72 in.
Chamfers to conserve volume

Work Station=
48 in. high



Rectangular Area=
72 in. x 30 in. x 60 in.
30 in. radius



In order to get ourselves acquainted with the 53 feet cubed volume requirement, we made volumes out of foamcore to get participants to test the forms following a procedure.

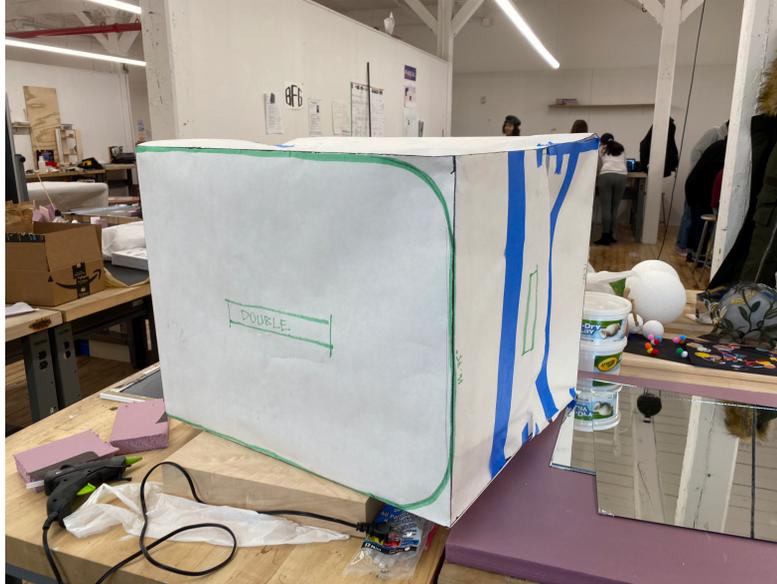
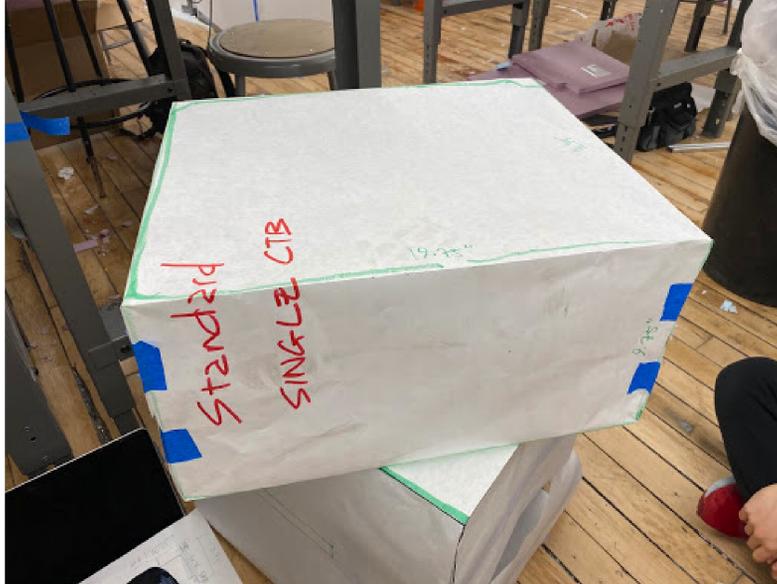
Here you can see that we came up with 4 different forms. Volumes 1 and 2 were made during the first week of ideation and Volumes 3 and 4 were made during the second week.

We found that after testing Volume 1 and 2, out of 8 participants, 75% preferred Volume 1 over 2 because 1 was "cozier" and 2 was too restrictive.

We found that after testing Volume 3 and 4, out of 13 participants, 84.62% preferred Volume 3 over 4 because 3 had a nice working space and 4 was too narrow.

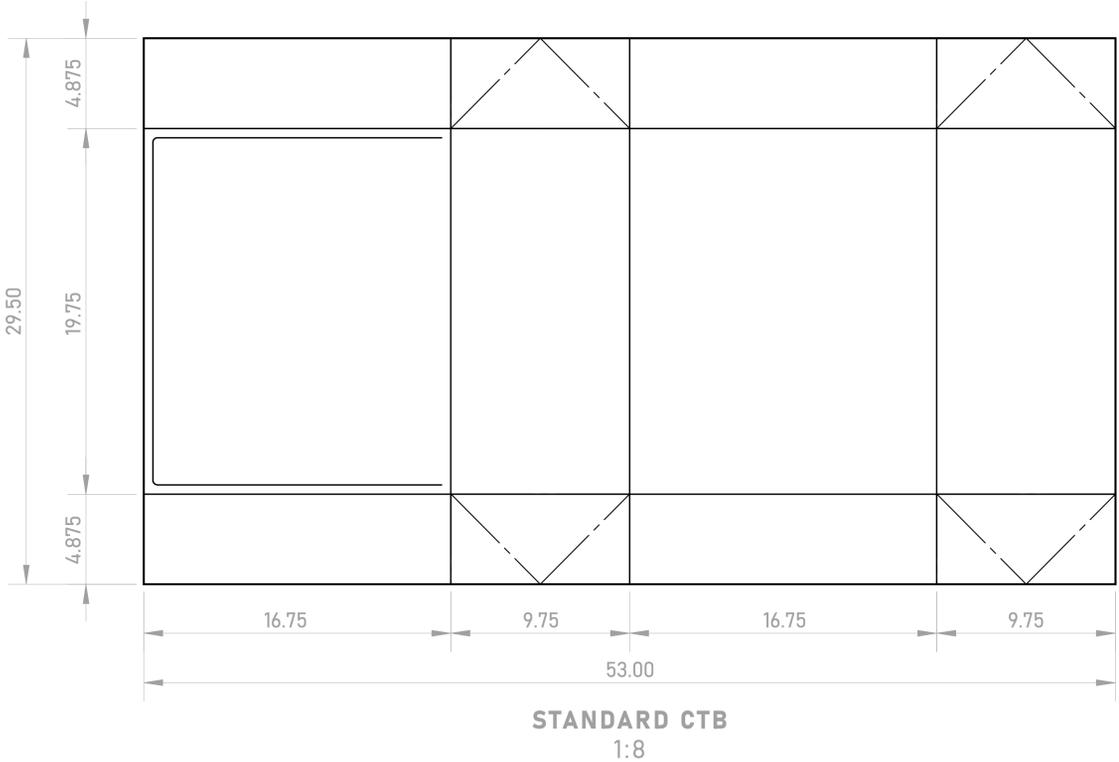


MCTB FABRICATION



In order to get familiarized with MCTBs, we first made them out of butcher paper to figure out how the bags fold and unfold.

Then we fabricated our own MCTB out of canvas to familiarize ourselves with how fabric behaves. We used canvas for this because nomex and canvas are similar in their physical properties.



ACOUSTIC MCTB



Double AMCTB



Standard AMCTB



The MCTBs serve many different purposes, like acoustic panel or radiation shield. Of the variety of MCTBs, we chose to re-purpose the Acoustic MCTBs, also called AMCTBs, since its noise reduction property can be useful for the astronauts when they sleep. Many spacecrafts have machinery operating at night, generating a great amount of noise. Some astronauts' sleep cycles could be disrupted by these irritations.

The AMCTBs provide acoustic dampening properties because of the 3 different layered textiles and materials: Nomex, Durette and Thinsulate.

Both Durette and Nomex are used for their high tensile strengths, and Nomex is highly resilient to both fire and radiation.

They assemble the same way as normal MCTBs but the inner 3M Thinsulate insulation absorbs sound as well.

Blue Nomex

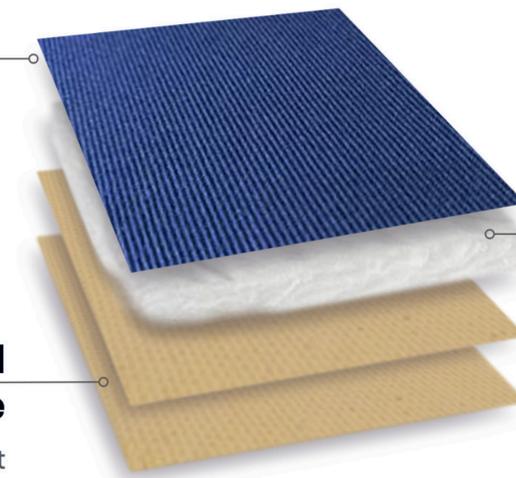
With a tensile strength of 340 mpa., **Nomex** is a meta-aramid, which makes it radiation and flame resistant

Gold Durette

Flame resistant

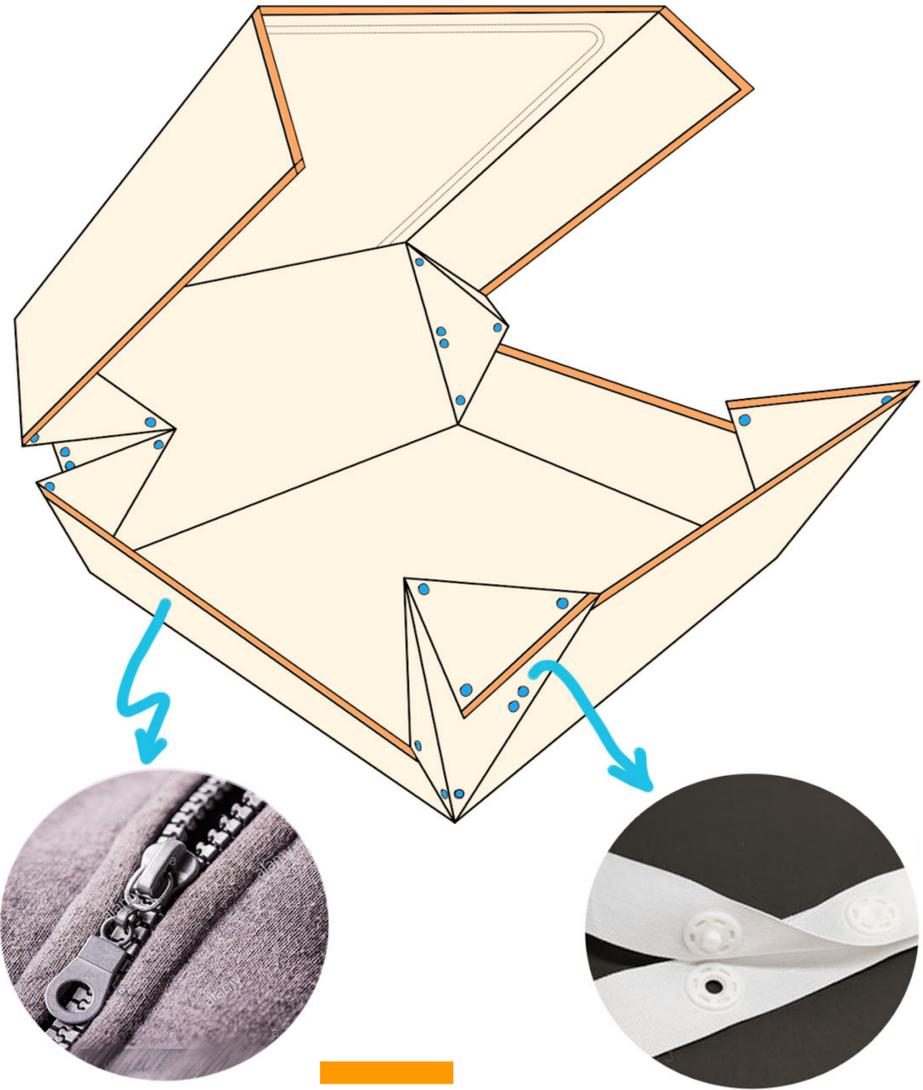
3M Thinsulate

The **Thinsulate** interfacing behaves as an acoustic insulation.



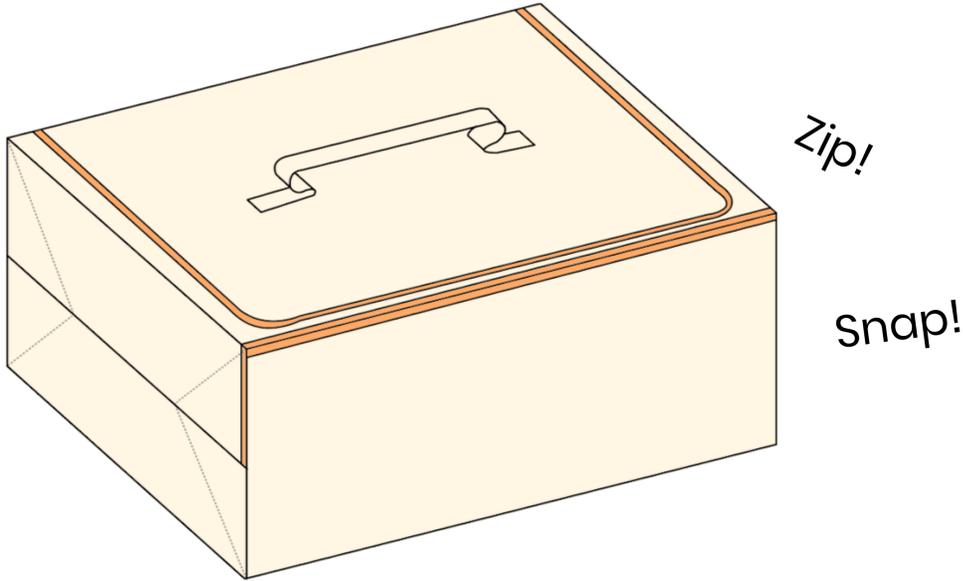
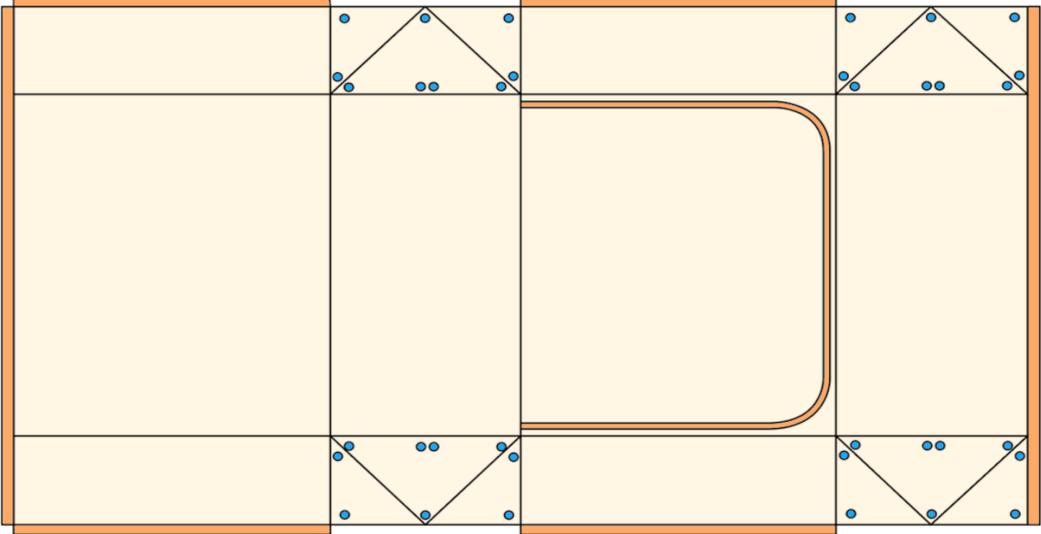
MCTB FASTENERS

Our investigation of MCTB attachment methods reveal that there are certain zippers and snaps on the bags that could be used to attach MCTB bags to one another, or same types of fasteners on extra materials. We decided to incorporate these designs to our final product.

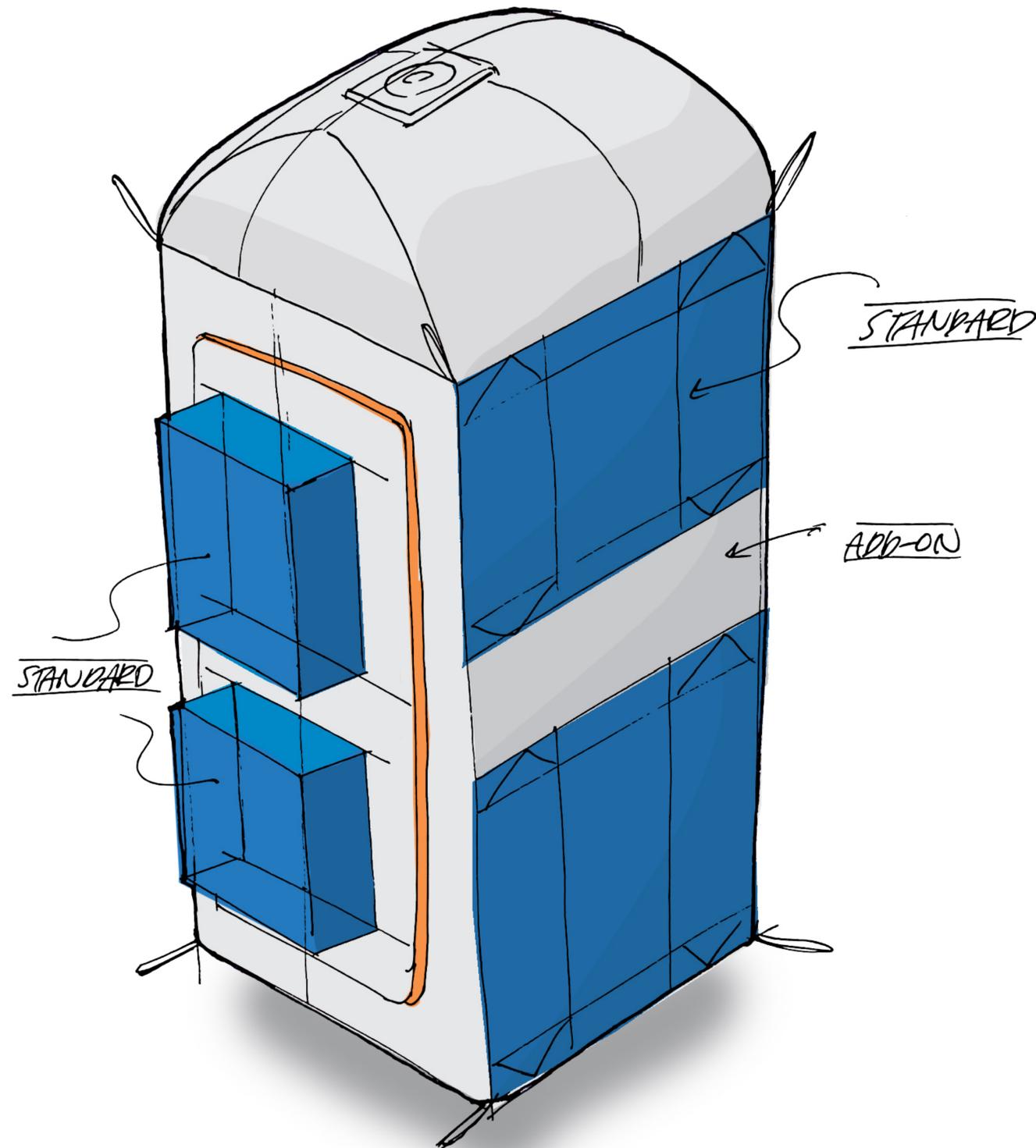


Zippers

Snaps



FINAL DESIGN

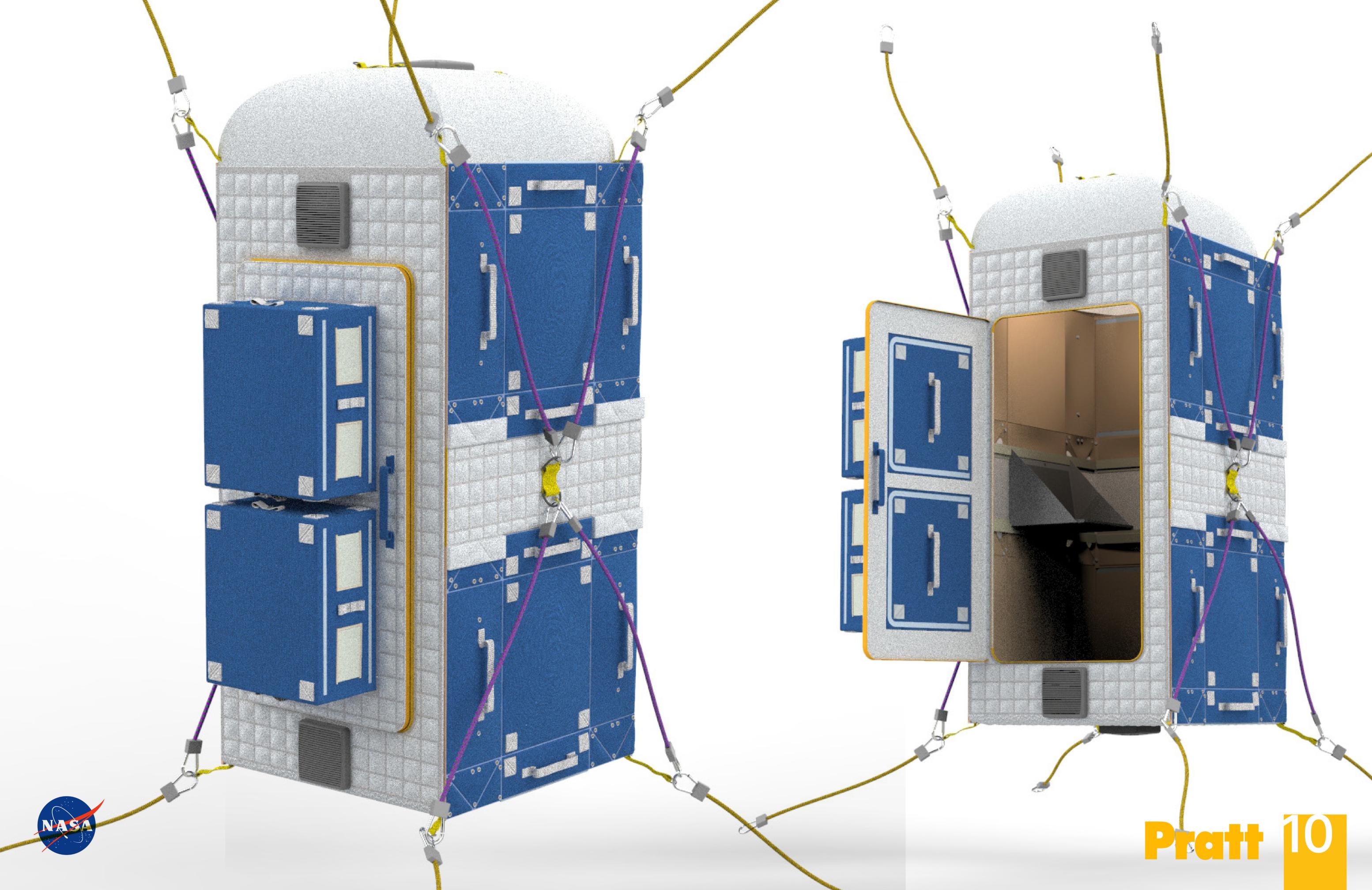


We combined the CAD iterations to produce our final design. The goal is to maintain the compartment's ability to be stowed away as a suitcase, while using only single MCTBs, the most abundant type of cargo transfer bags on spaceships. The single MCTBs are then attached to an add-on BFG kit for easy assembly as well as maximized space.

The final design repurposes 4 Unfolded single AMCTBs and 2 Bagged up MCTBs to be attached to the compartment.

Four of them make up the walls of the compartment and the other two behave as storage on the zip up door.

The BFG kit would fasten to the existing snaps and zippers on MCTBs for ease during assembly and stowage.



Pratt 10

SPECIFICATIONS

-The final compartment measures to be **36.25** inches long, **33.5** inches wide, and **82** inches tall.

-The final volume measures to be about **53** square feet.

-In total, the compartment uses **6** single MCTBS. **4** of them unfolded, and **2** folded as storage.

-**4** push-pull configured fans are attached to the door, the floor, and the ceiling.

-**Nomex, Durette** and **Thinsulate** are the materials of the BFG kit, similar to the AMCTBs.

82"

36.25"

33.5"

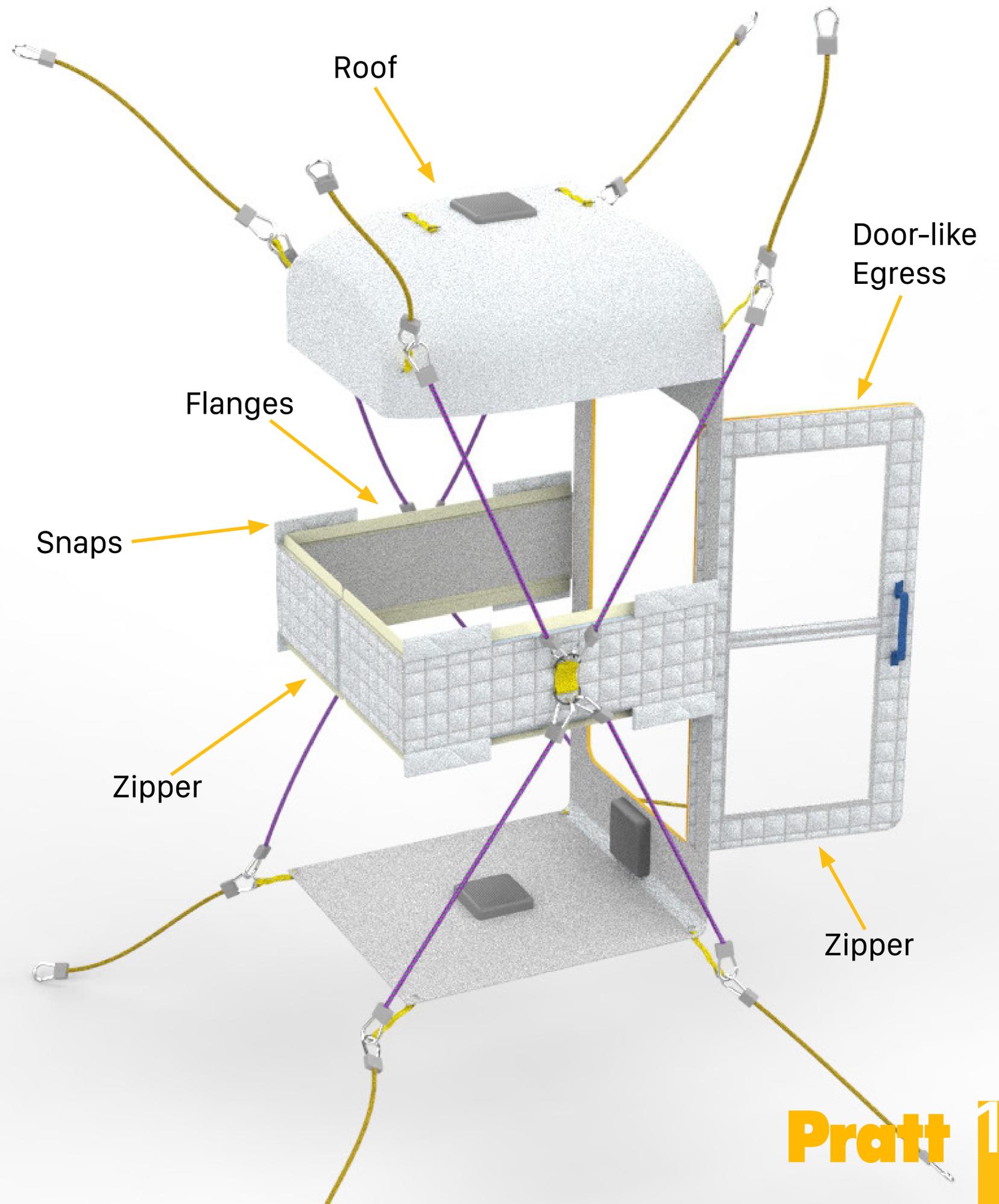


BFG KIT

Our solution to the design challenge uses a kit assembly to accommodate the AMCTBs without any further modifications.

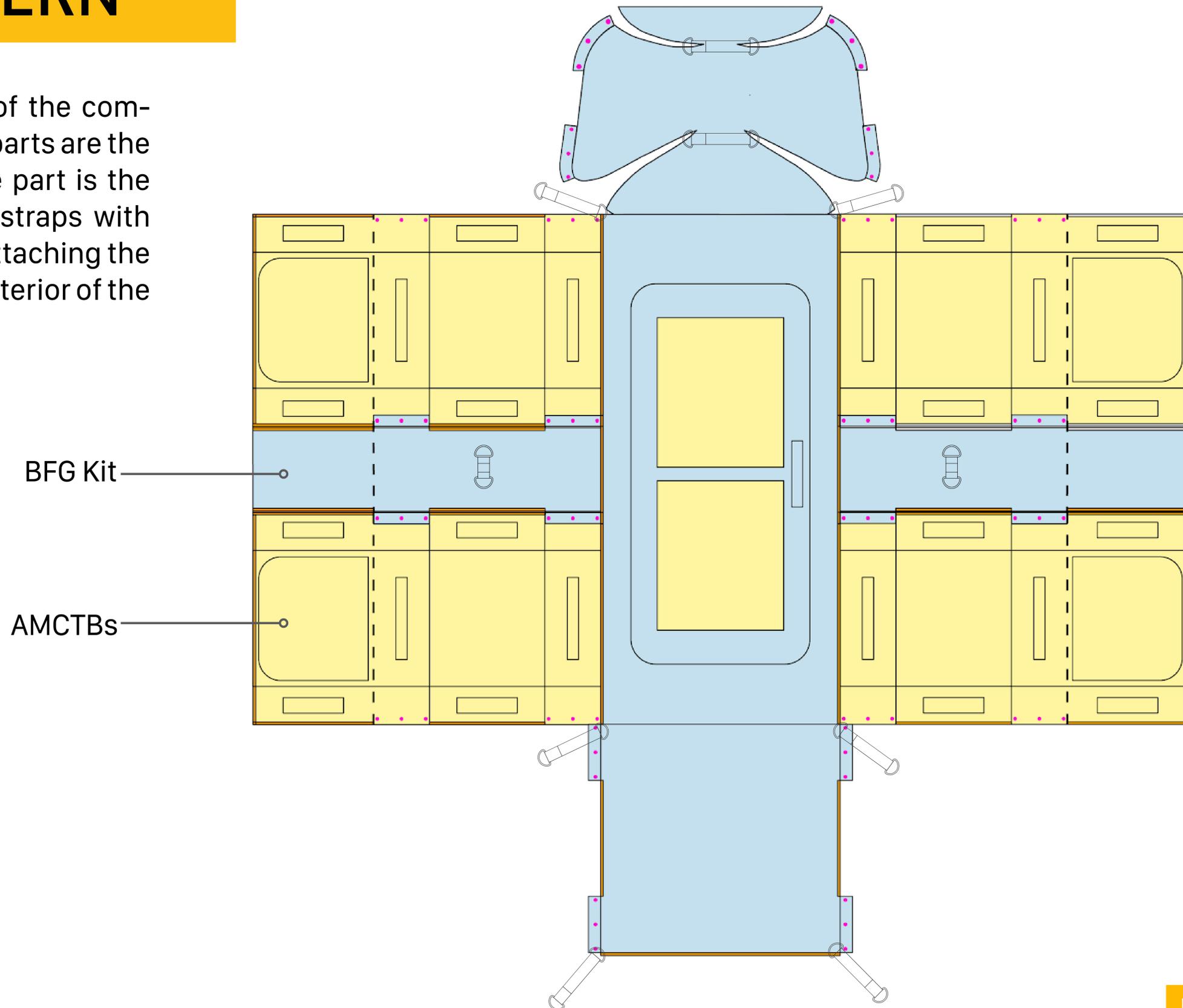
The kit uses the existing snaps and zipper fasteners on the MCTBs.

We chose to use add-on material between the mctbs to improve the ease of assembly. The zippers and the snaps match with the existing ones on the MCTBs, which would connect seamlessly. The kit would stow away into two CTBs attached to the door.



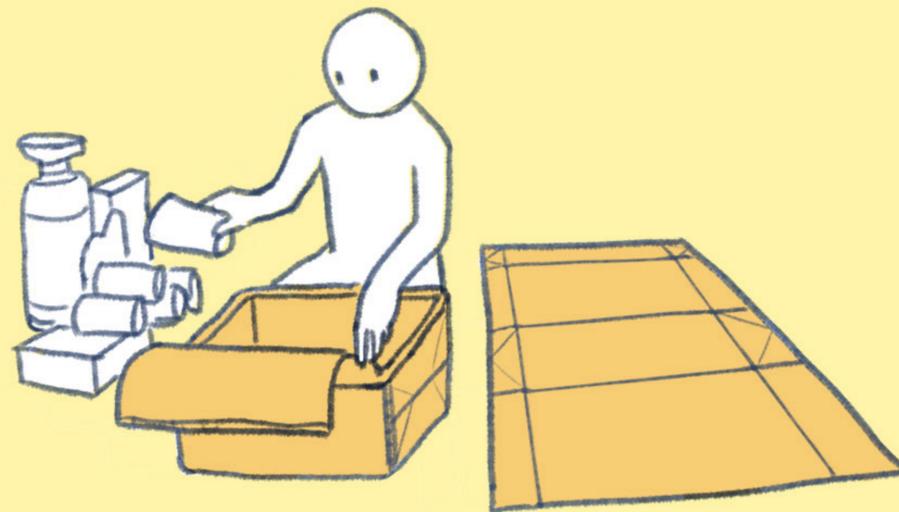
FLAT PATTERN

This is a flat pattern of the compartment. The yellow parts are the AMCTBs, and the blue part is the BFG kit. There are also straps with D-rings available for attaching the compartment to the interior of the spacecraft.



How is the compartment used?

① Prepare 6 standard AMCTBs (4 of them unfolded).



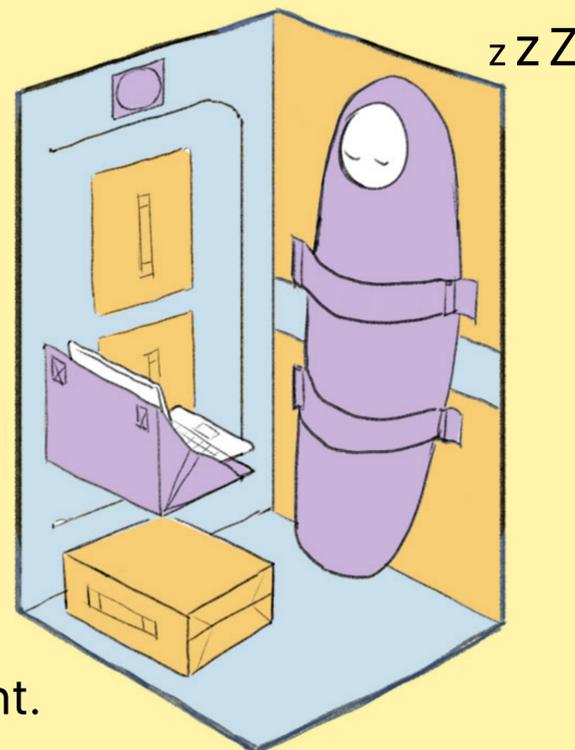
② Assemble the MCTBs and install attachment features.



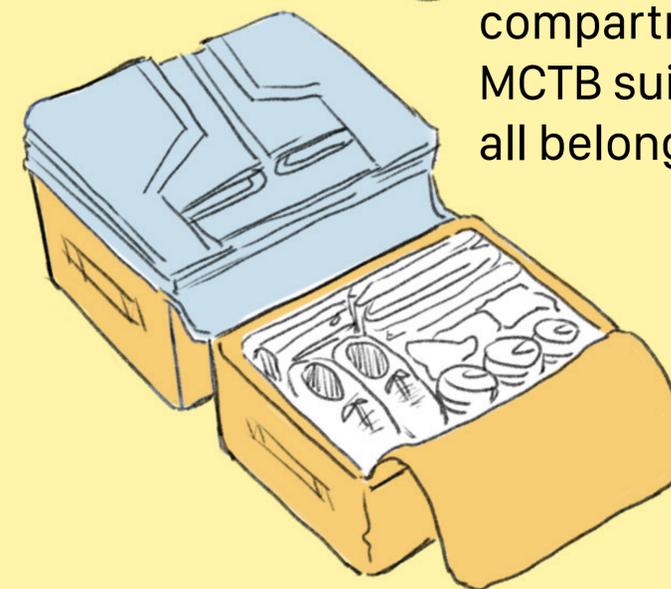
③ Attach the compartment to the interior of the spacecraft.



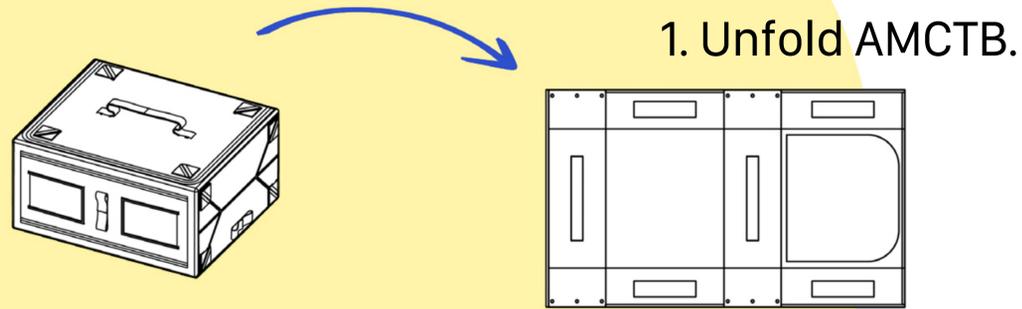
④ Sleep, relax, read, work and change inside the compartment.



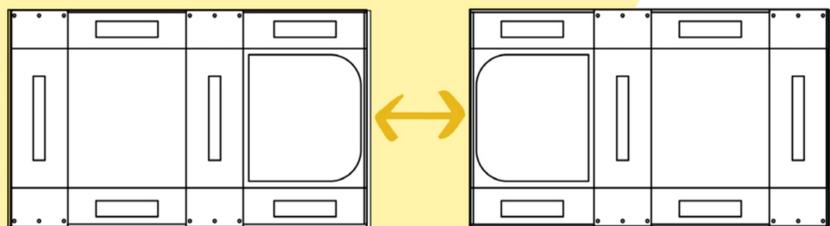
⑤ Easily stow away compartment into a MCTB suitcase; keeping all belongings inside.



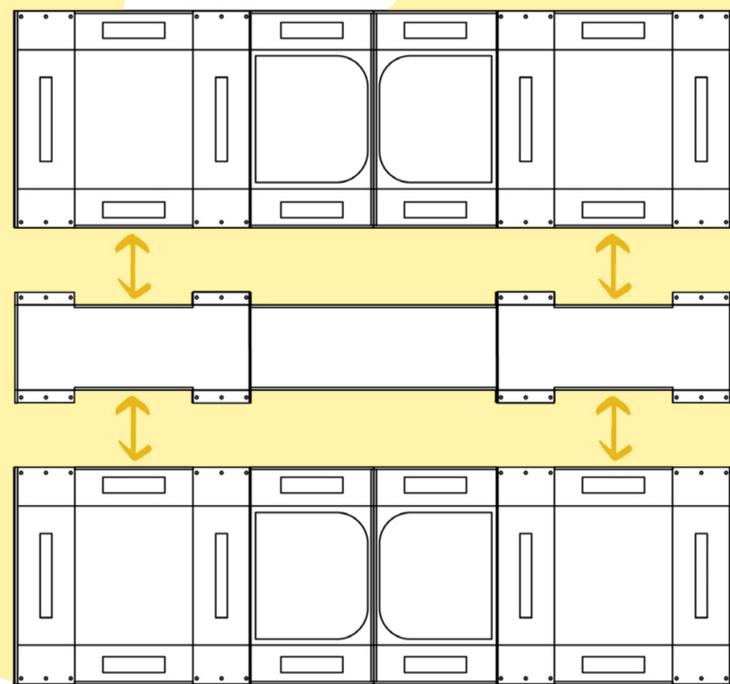
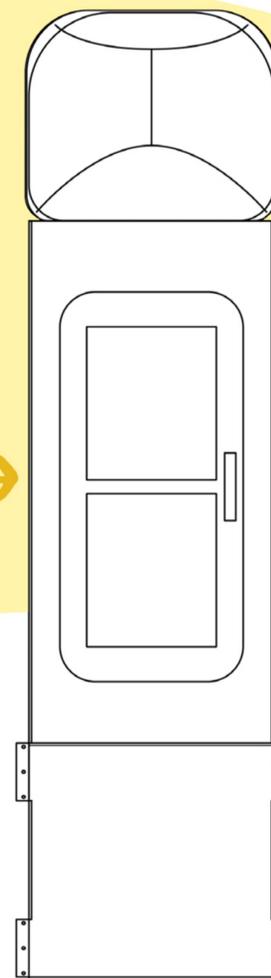
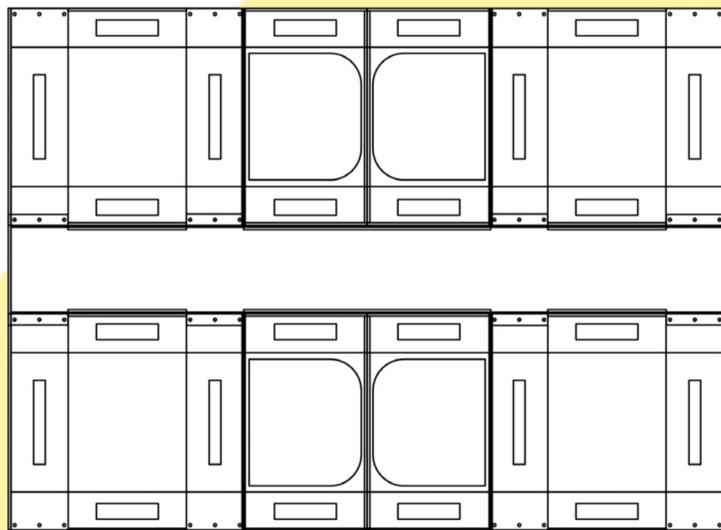
Deployment Method



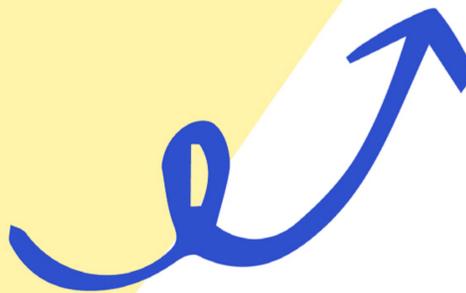
2. Attach 2 flat AMCTBs with zipper.



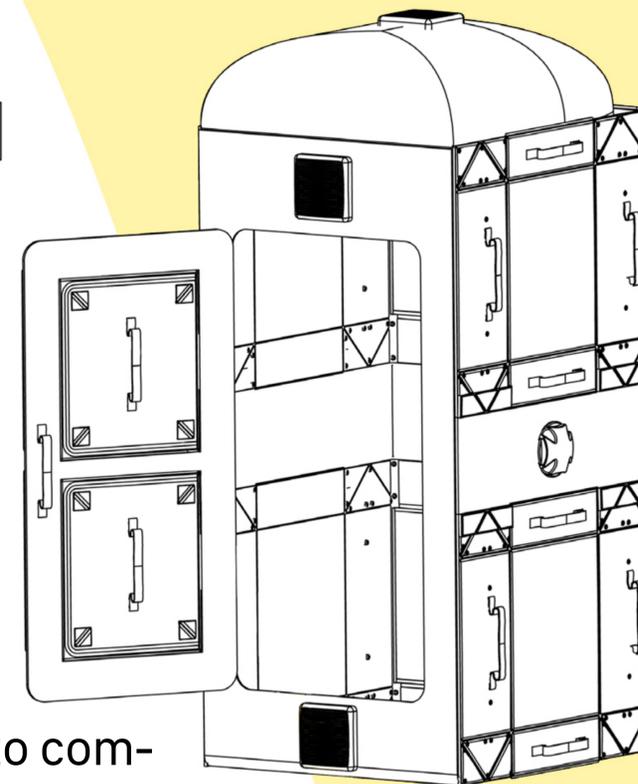
4. Use zippers to attach the middle panel to the door.



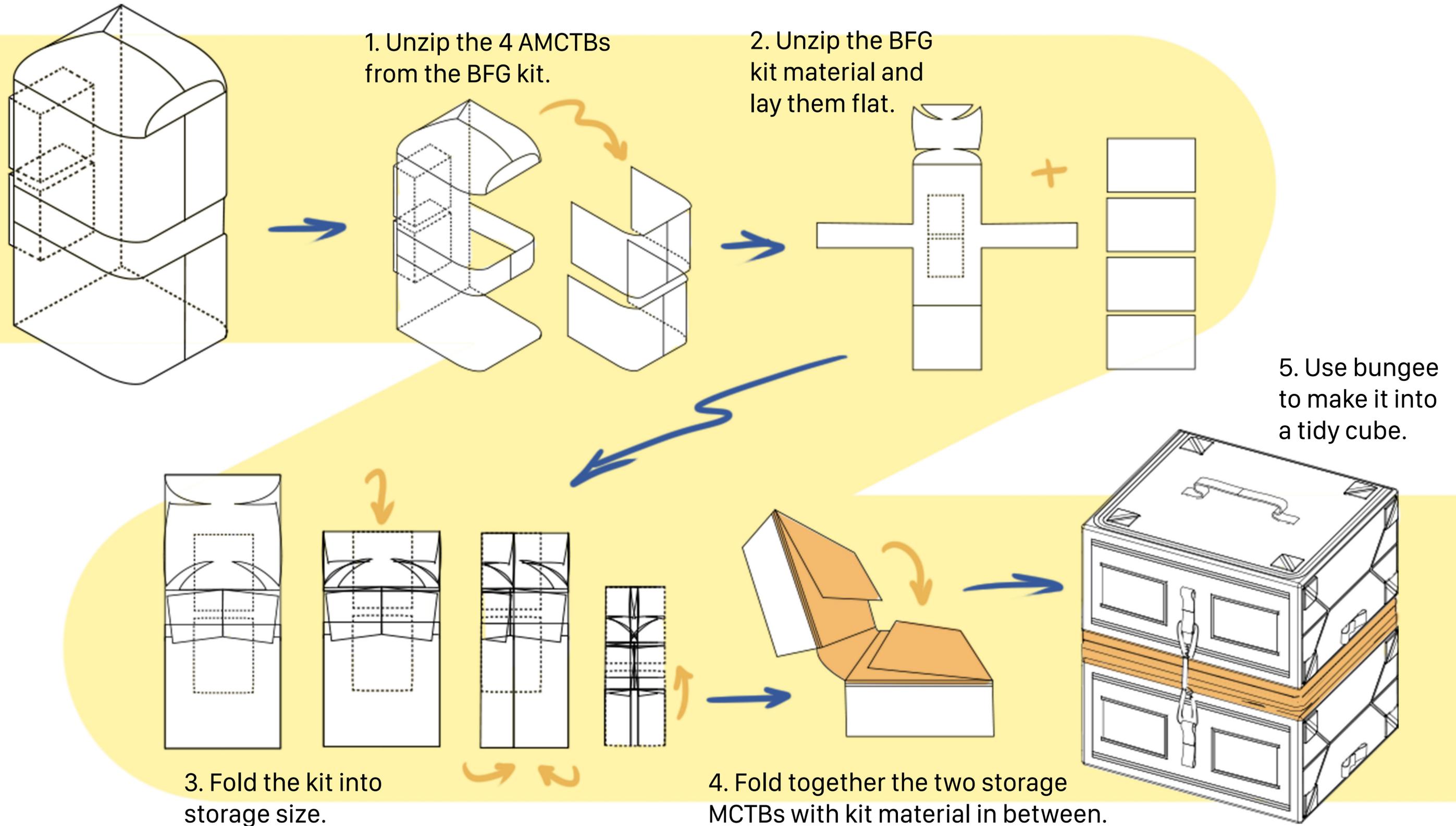
3. Attach 4 flat AMCTBs to the middle of the BFG kit using snaps.



5. Attach any personal item, kit or storage to complete the apartment.



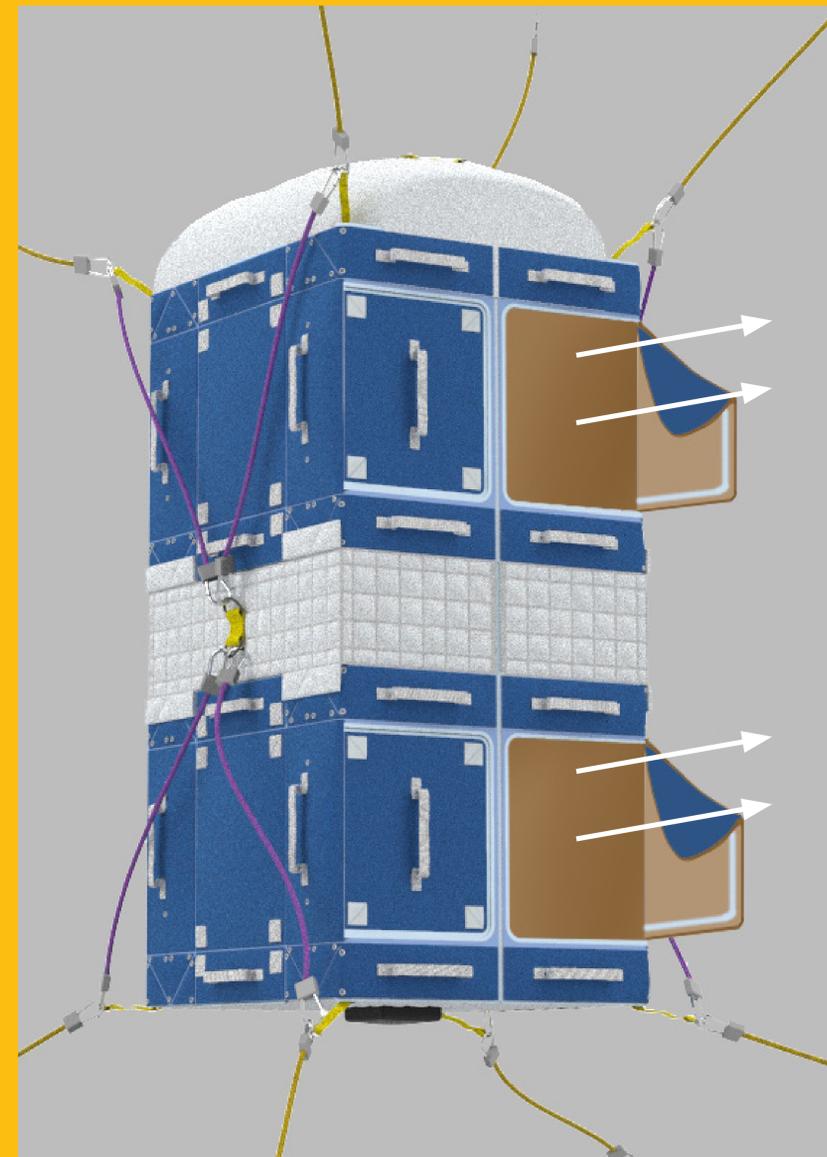
Stow Away Method





VENTILATION

There are a total of 4 fans installed. Besides the two fans on the door, there are 2 additional on the top and bottom of the compartment.



The MCTB openings can also act as windows when unzipped.



PUSH-PULL FANS

Unlike placing 2 fans side by side, push-pull fans provide sufficient airflow by one fan propelling air into another. This reduces noise and heat, which is often the problem with the side by side fan system. It also provides additional safety measures, because if one fan fails, the other will continue to operate.

In total there are 4 Push Pull configured fans that would be placed on the top, bottom, and the wall of the compartment. 2 would be in use and 2 would act as back-up. There will be 2 Outlet and 2 Inlet fans.



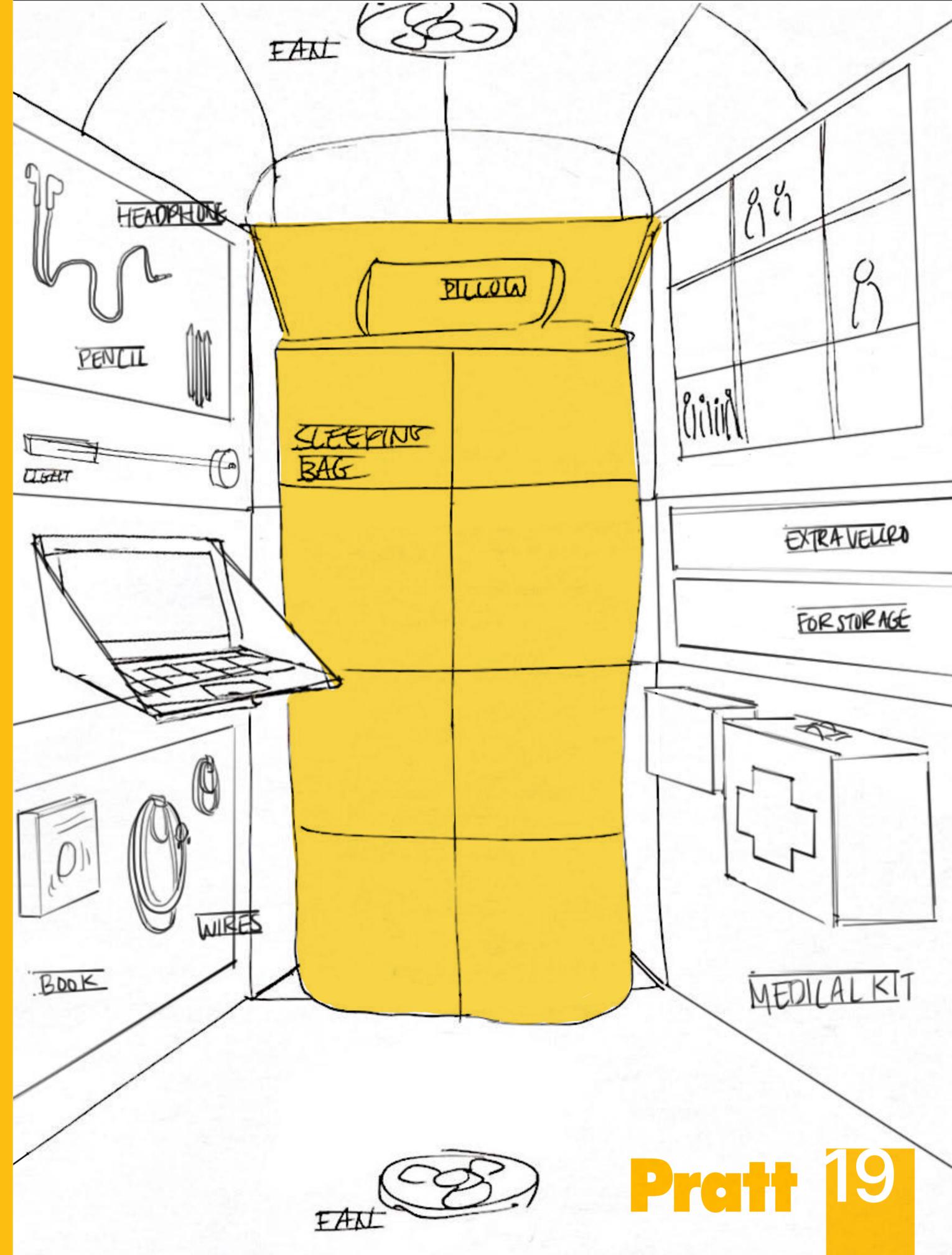
Push-Pull System Fan



SLEEPING

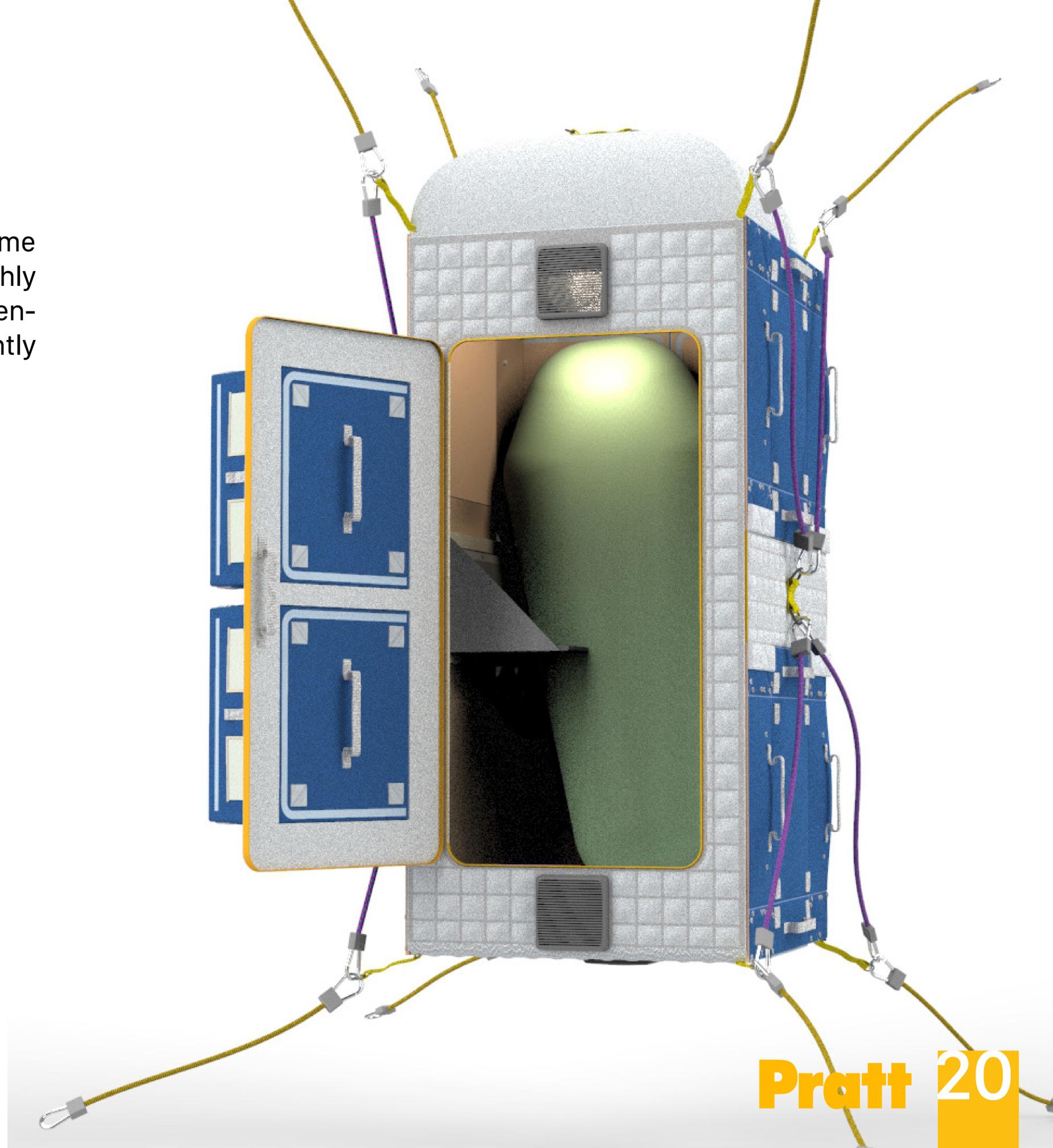
The sleeping bag is attached to the wall opposite to the door. This configuration is similar to that of the existing crew compartments on the ISS.

At the same time, the interior attachments of the compartment is not at all locked at their current placements. We hope that the astronauts can have the freedom to configure their compartment according to their personal needs. For instance, they could sleep in any orientation they desire -- since it is reported some astronauts enjoy sleeping upside down, horizontal, or in any position that give them a sense of the ceiling and the ground.



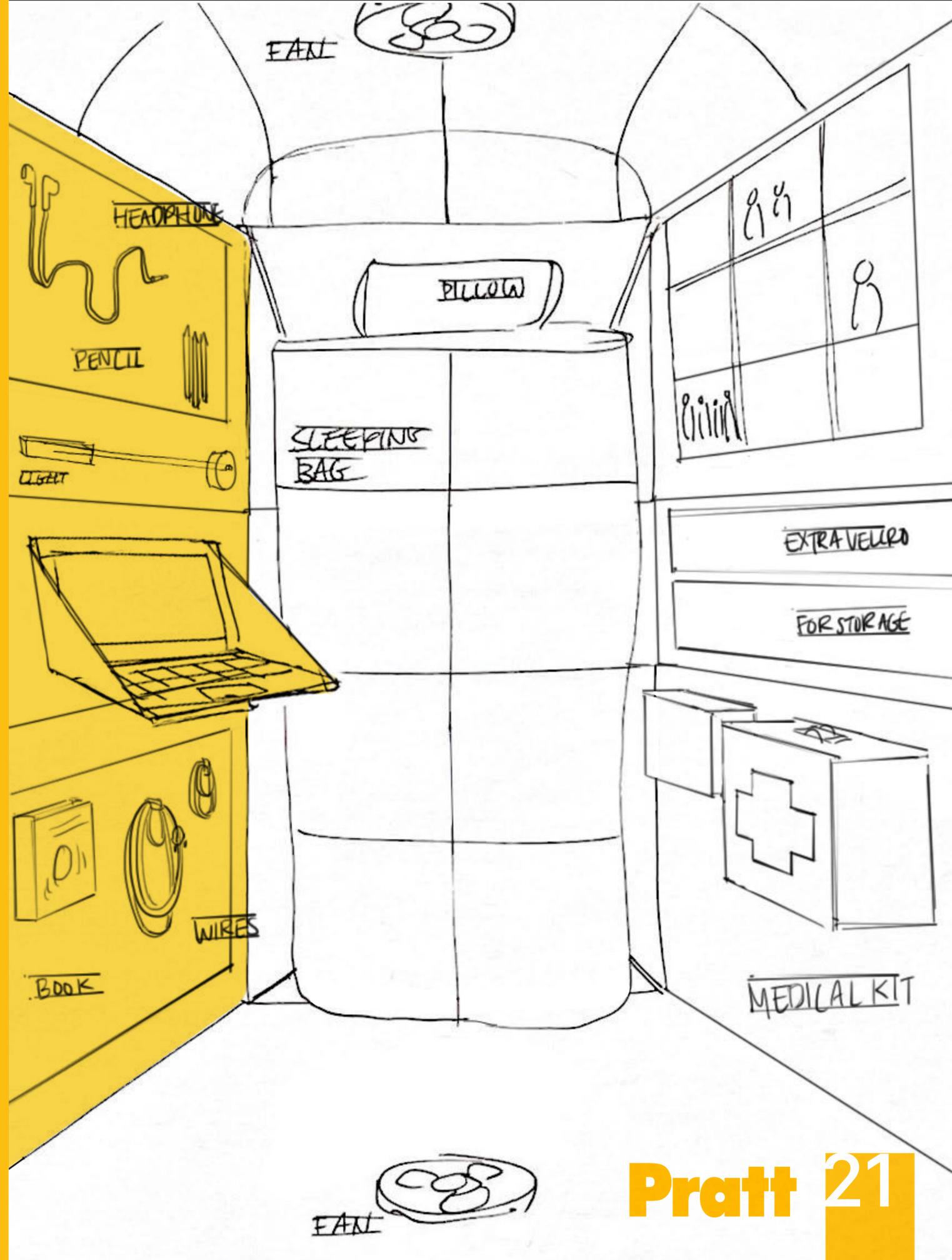
SLEEPING BAG

The sleeping bag for this compartment will be the same as the one currently used on the ISS. You can see roughly where the sleeping bag will be in the context of our rendering. There volume of the compartment sufficiently accomodates that of the sleeping bag.



WORKSPACE

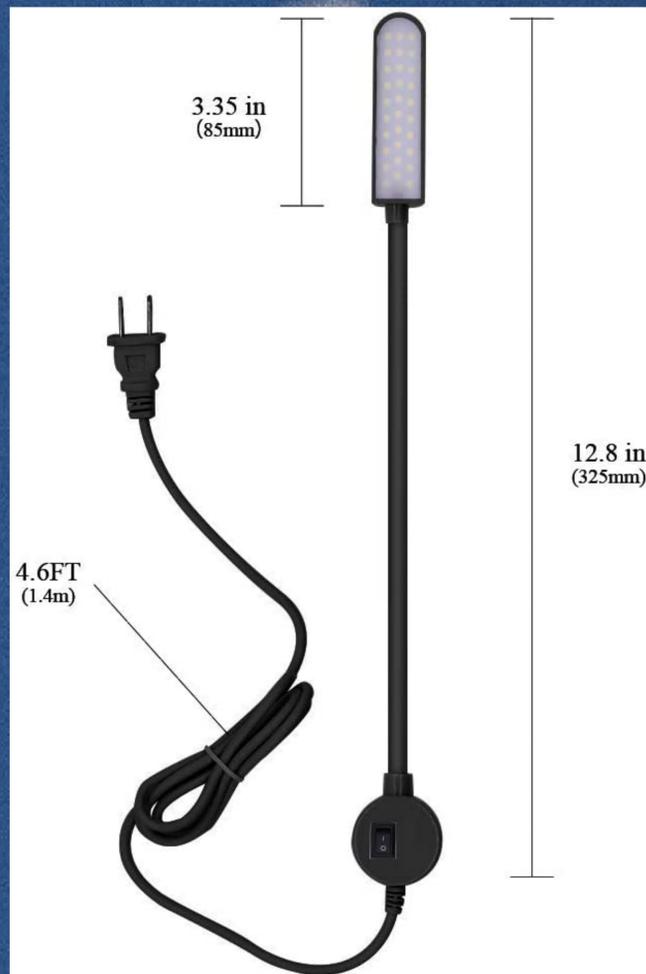
On the left side of the wall we have the workspace for astronaut. This space replaces the idea of a work ledge from our previous ideations, to preserve more space both inside and outside the compartment. There are accessories such as headphones, pens, pencils, wires, and books, and a light and computer stand. Most of these items can be attached to a pad of velcro that is attached to the single MCTBs and/or the BFG kit.



OUTSOURCE:

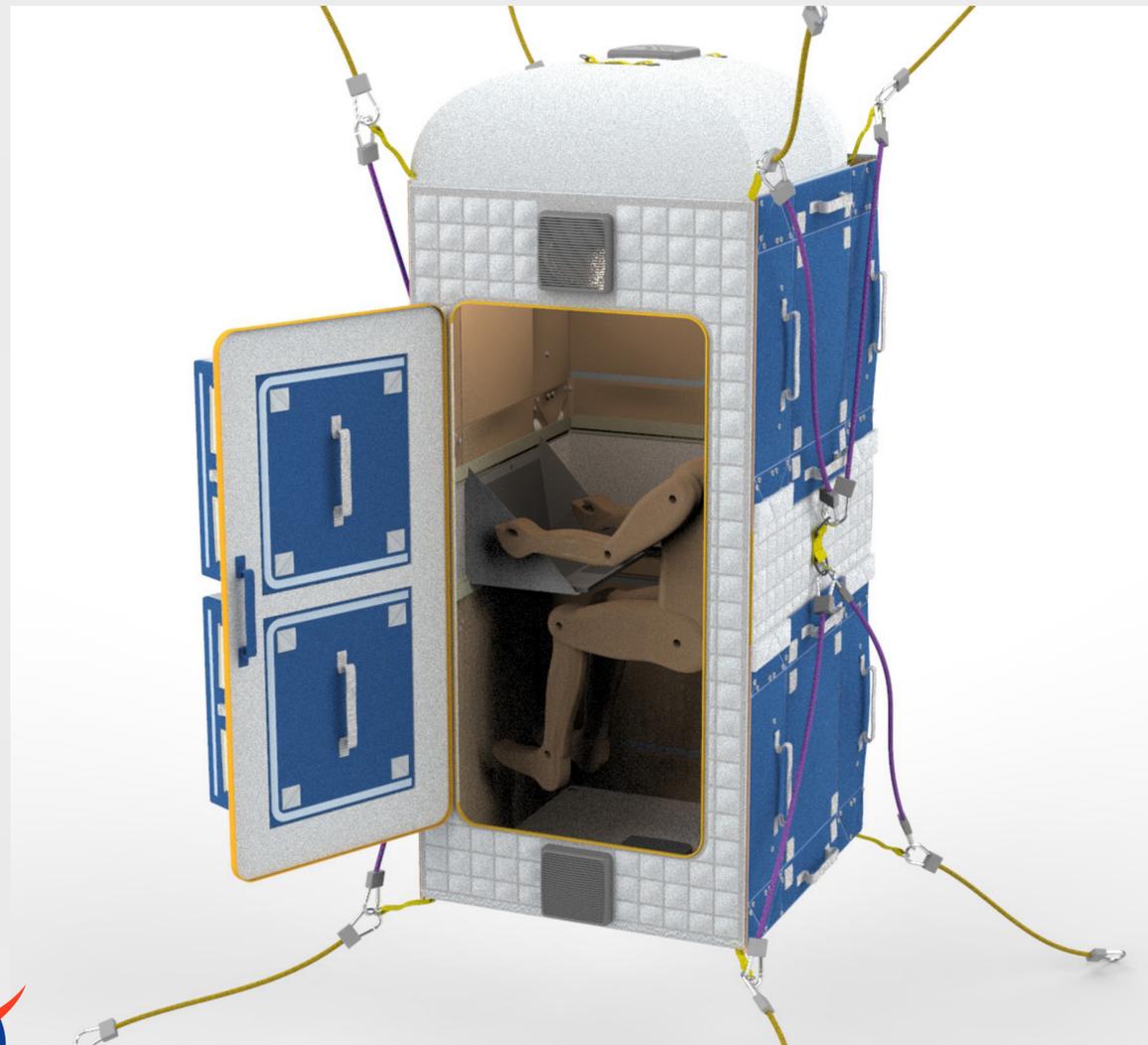
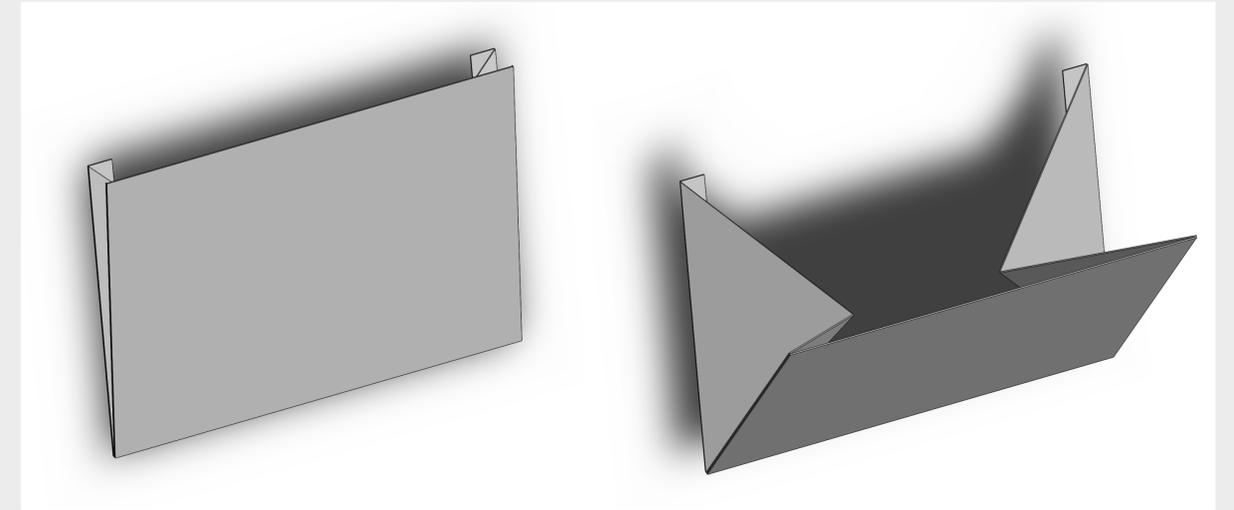
GOOSENECK LIGHT

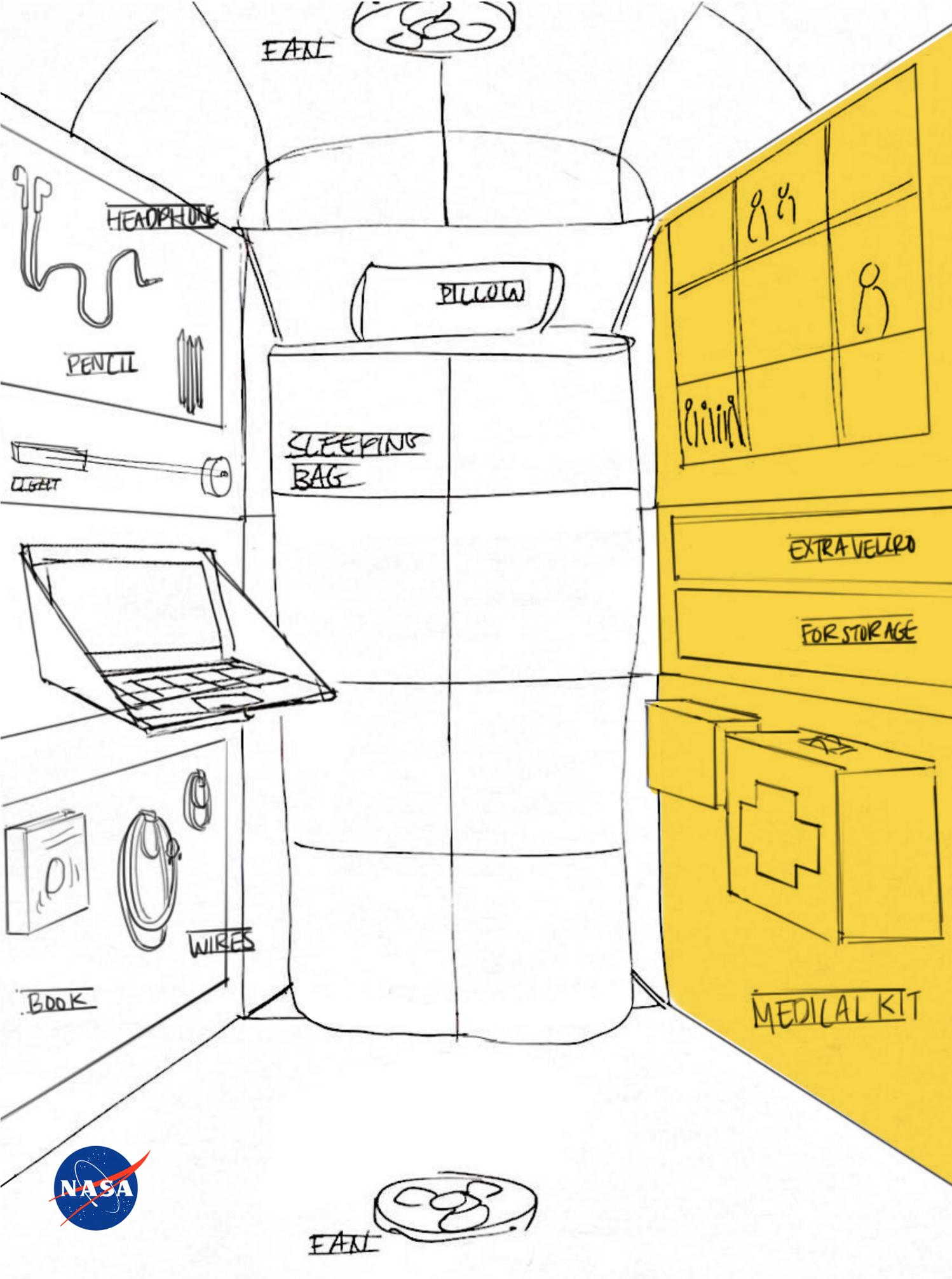
This is an LED gooseneck light we propose NASA to outsource. It has an adjustable neck and is portable. There is a magnetic base to hold the light in place. Often, the light is used for drill presses, sewing machines, music stands, etc.



COMPUTER/BOOK MOUNT

The computer and book mount for the compartment is made out of fabric. It is retractable which folds out when in use and folds up flat against the wall when no longer in use to save space. The mount could be attached to the BFG kit and stowed away with the kit, due to its compact quality. The gooseneck light can also be attached to the mount.



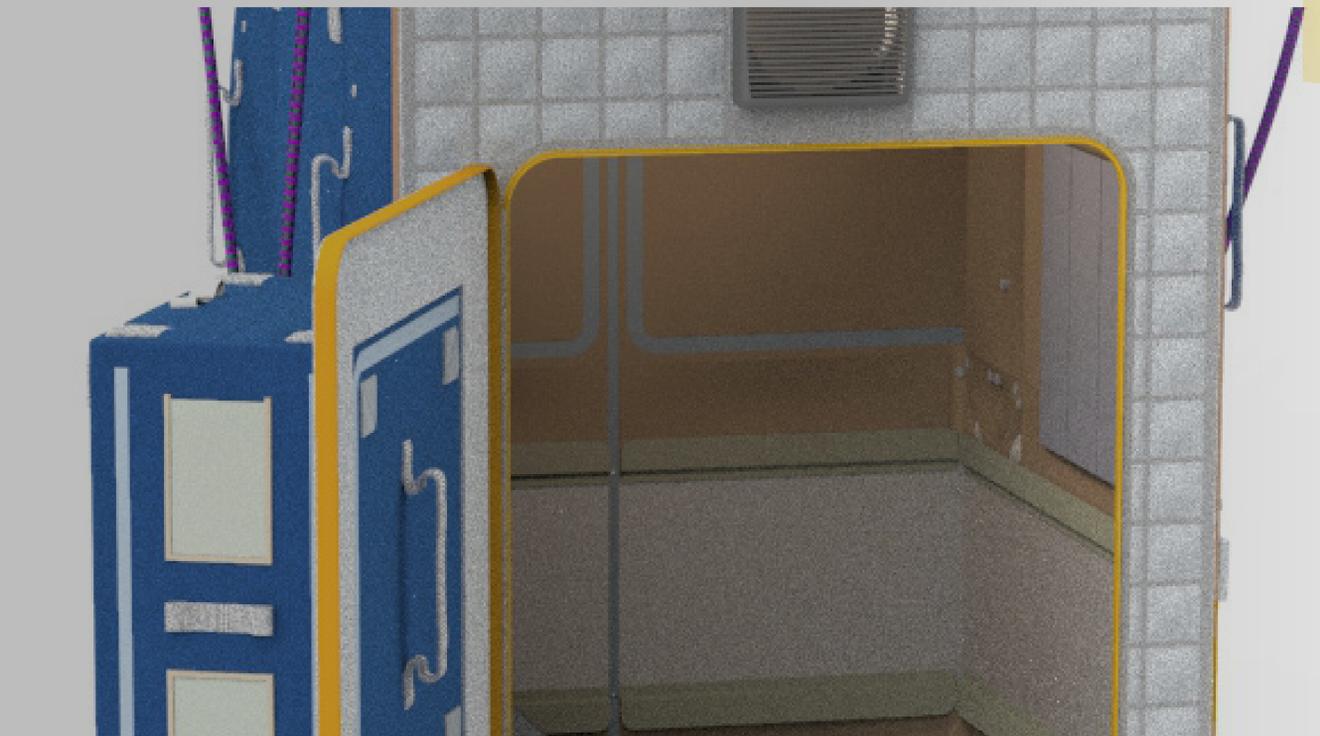


PERSONAL ITEMS

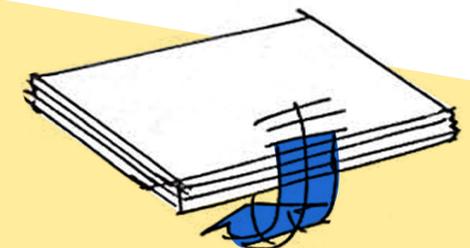
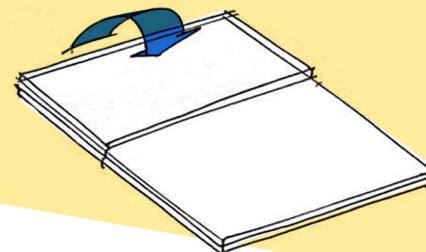
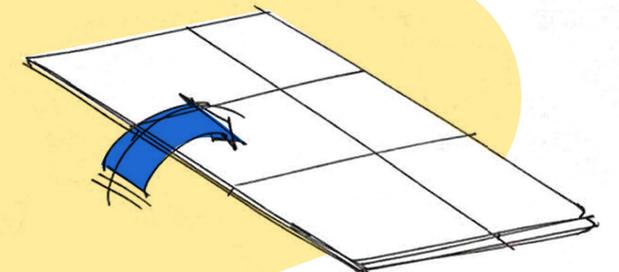
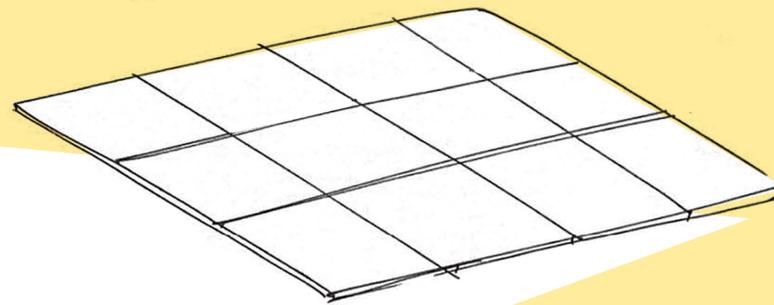
On the right side of the wall is where astronauts can keep their personal belongings. This include their photographs, hygiene kits, medical kits, make-up kits, emergency kits, and more. These items are attached to the wall using Velcro and the area is fully customizable. There would also be Velcro strips along the sides to attach extra things, especially smaller items like pen & paper, toothbrush & toothpaste, and utensils.

PHOTO SLEEVES

From our research into astronauts' lives, we found that a majority of their personal belongings are photographs. Thus, we created a portable photo sleeve for astronauts to keep reminders of home and their loved ones in their compartment. It is made out of fabric and has 12 slots for photos. The sleeve can be folded down into a 4"x6" photograph-sized pack for portability.

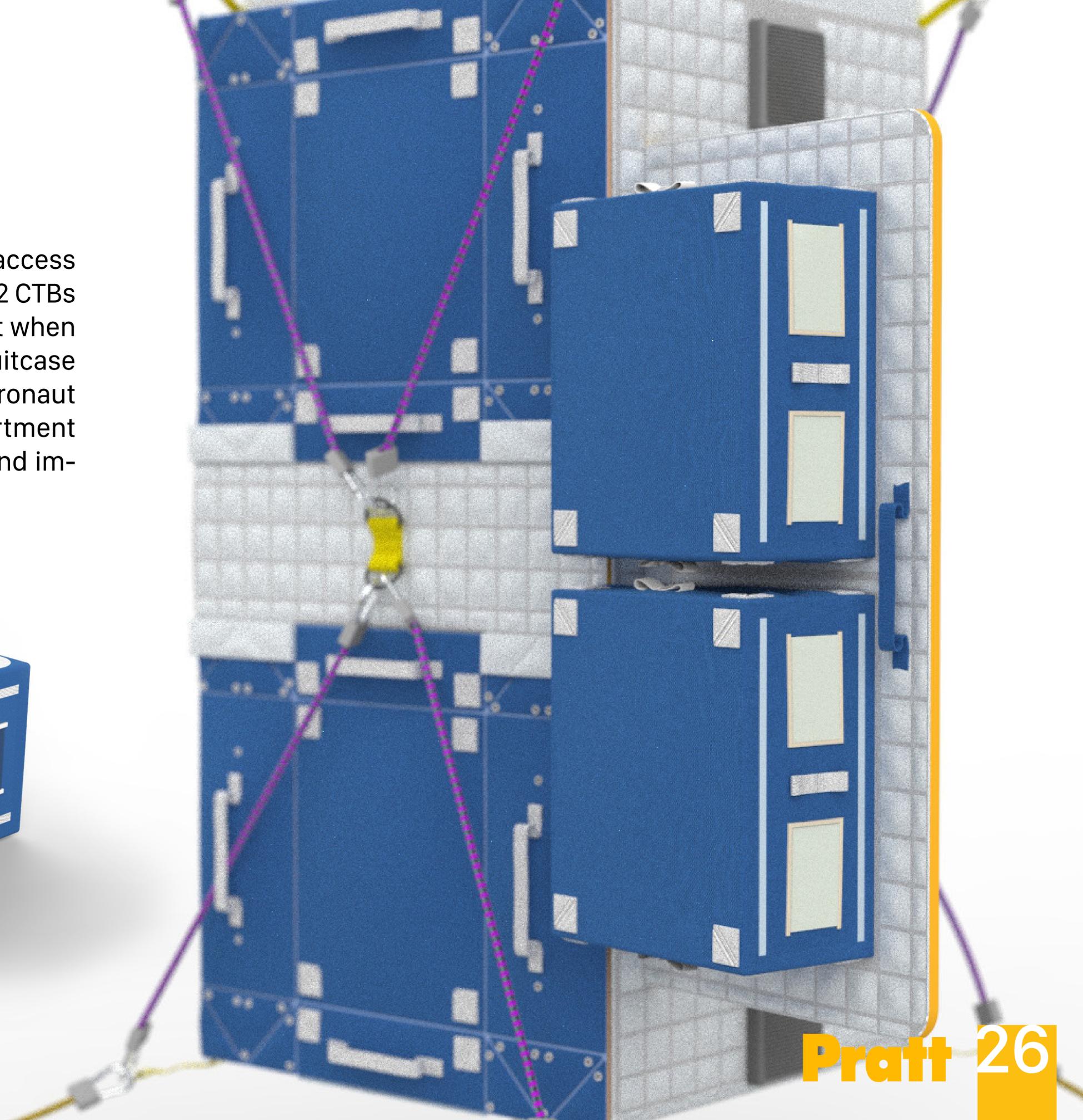


FOR THE PHOTOS



STORAGE

For bigger storage, astronauts will have easy access to their belongings from the inside using the 2 CTBs attached to the door. These can remain intact when the compartment is stowed away into the suitcase form, keeping the belongings inside. The astronaut can also bring another one inside the compartment as extra storage, for items they need quick and immediate access to.



ATTACHMENT METHODS

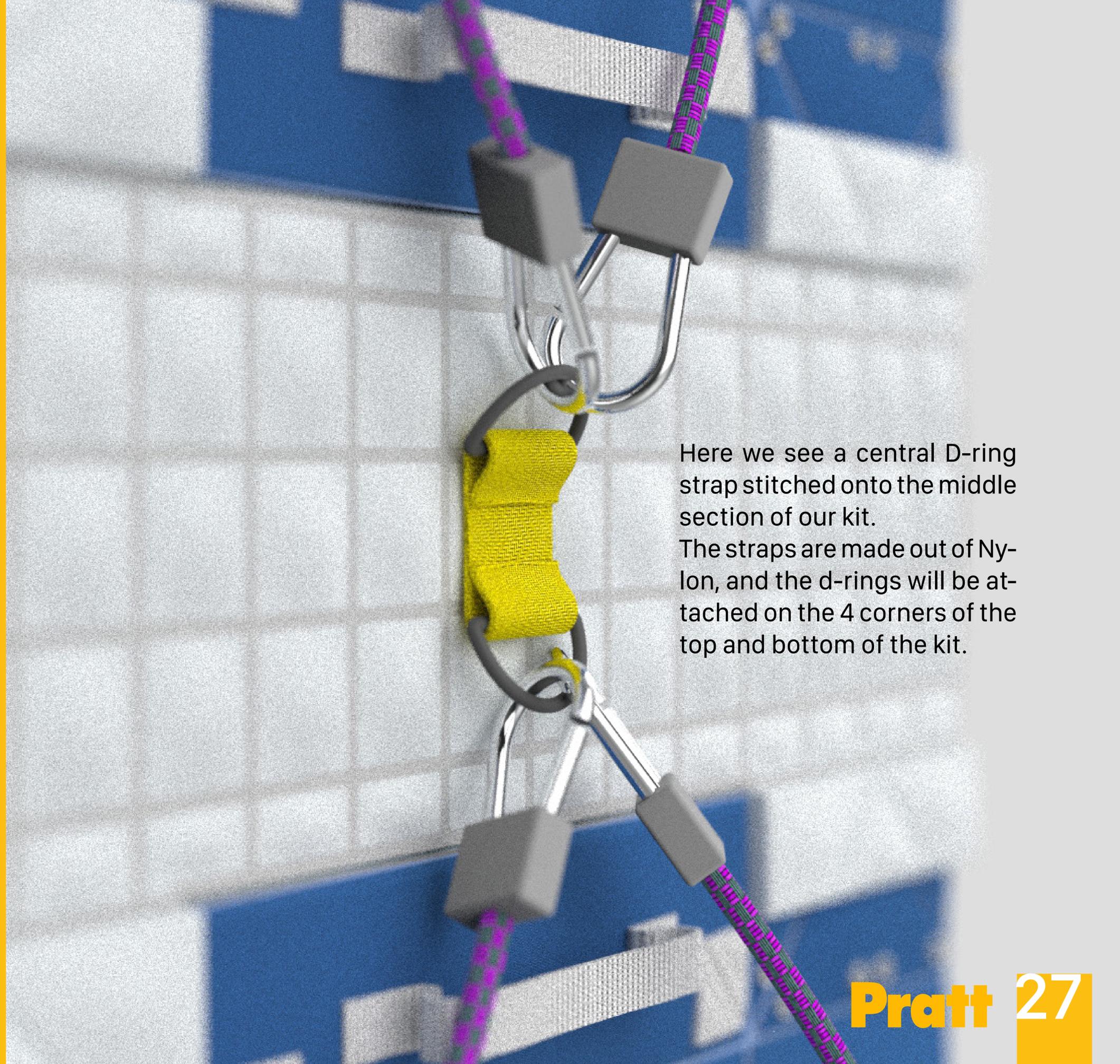
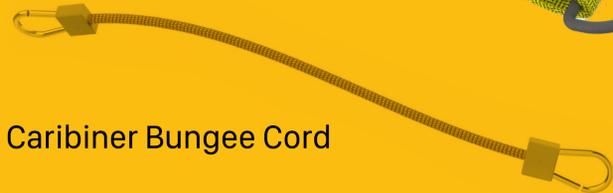
For the interior of the spacecraft

To attach the compartment to the interior of the spacecraft while also keeping the structure taut, we decided to use caribiner bungee cords and d-rings. They are placed at stress points of the compartment. There would be a central D-ring strap stitched onto our kit for caribiner bungee cords to clip onto our kit and the walls of the vehicle to reinforce the structure.

D-rings with nylon strap



Caribiner Bungee Cord



Here we see a central D-ring strap stitched onto the middle section of our kit. The straps are made out of Nylon, and the d-rings will be attached on the 4 corners of the top and bottom of the kit.

FUTURE DEVELOPMENT

After speaking to our mentors about the final compartment design, we have come up with a few ways to further improve our project. Our next steps would be to produce a physical prototype with fasteners. It will be used to conduct tests in stowage, assembly, and user experience. From this we can produce clear assembly instructions for less hassle. And additional tests of air ventilation would be taken. If possible, the compartment could be tested on users in micro-gravity.

Additionally, we could add stiffeners to the BFG kit fabric, to hold its shape. Then, we would explore a partial stowage solution; in other words, busy astronauts might not always have the time to fully assemble and disassemble the compartment. So, perhaps there could be an lazy way to “make the bed” for the astronauts. Similarly, to preserve time, the door might use a latch or a magnet.

For further logistics reduction, the BFG kit might change to be a new kind of MCTB that can also be used for cargo transfer, but then unfolds to become part of the compartment.





THANK YOU!

Professor Rebeccah Pailes-Friedman
Captain Robert Trevino
And our fellow classmates

Further Appreciations:

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Prof. Chamille Thayer
Prof. Peter Ragonetti
Prof. Scott Lundberg
Prof. Brian Bjelovuk
Prof. Mark Lim

Prof. Willy Schwenzfeier
Prof. Deb Johnson
Prof. Hannah Berkin-Harper
Prof. Max Diamond
Prof. Jobe Bobee
Prof. Lucia De Respinis
Prof. Lawrence Au

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