# Kwadropus Duster Robot

# Duster Arm

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**The premise**

- Octopuses live neutrally buoyant in the water—they don't really sink and they don't really rise up, they can rest in the water without moving up or down. This is similar to how an astronaut floats around in the Neutral Buoyancy Lab when they train for a space walk on the space station. When astronauts are inside the space station in micro-gravity, it is similar to being neutrally buoyant—they don't sink or rise. The air has a lot less mass so it is very difficult to move enough air to 'swim' when on the Space Station.

**The Proposal:**

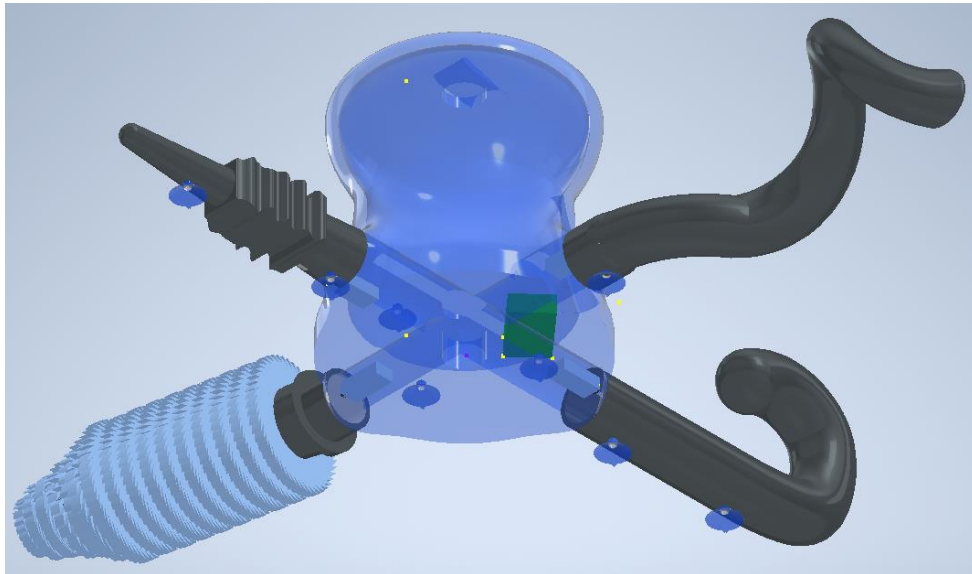
- HUNCH would like to demonstrate the feasibility of an octopus like, soft robot that can crawl around the inside of the Starlab or Axiom Space Stations using flexible arms and suction cups on handrails and flat or curved, smooth surfaces for mobility and uses some kind of duster appendage to remove dust from the walls of the space station. The idea is that it needs to work kind of like a Roomba (but doesn't vacuum up the dirt) for a zero-g environment. An Octopus has 8 arms but HUNCH expects that our dusting robot may only need 4 arms—which makes it more of a Kwadropus. Like an octopus, each of the 3 mobility arms need to be able to act independently to find something to grasp and hold to prevent the Kwadropus from pushing away from the wall. Two suction cups per arm will need to be placed where they will have the most chance of being used. While the 4th arm, a duster arm, is cleaning, at least one of the mobility arms has to be holding the Kwadropus onto a wall or handrail either with a grasping of an object or a suction cup to a surface to keep it from being pushed away from the wall and floating aimlessly. If somehow the Kwadropus does get pushed away from the wall and handrails, the Kwadropus will use some kind of octopus like propulsion to push itself back to the wall.

A Roomba is a small, robotic room sweeper and vacuum cleaner. We are looking for a duster without the vacuum suction.

# The Teams

- The **Kwadropus Robot** is divided up into **five different projects** to allow small teams to concentrate on what they are good at and increase each team's chances of success. This is how NASA or any engineering company would develop a new product. Part of each team's responsibility is to be aware of what the other team's requirements are and to stay on their own requirements so everyone continues to work for the same goal and final product.

  - Mobility Arm Team
    - Develop one robotic arm with minimal amount of rigid parts that can pull itself from one location to another using a handrail or other
    - Can rotate to grasp in multiple directions
  - Suction Cup Team
    - Develop a suction cup that can conform itself to a smooth but rounded surface and suction onto it. This could be size related—small suction cups can attach to smaller curves, big suction cups can only attach to fairly flat surfaces.
  - Propulsion Team
    - Develop a propulsion that simulates how an octopus uses a directional jet of water to move itself if it can't grab or grip the wall or handrail.
  - Duster Arm Team
    - Develop a flexible and moving dusting arm that will be able to remove and absorb dust as the robot moves around the module walls without liberating dust into the surrounding volume. (slow may be important)
  - Control Team
    - Develop a method of hive programing similar to an octopus where each arm is able to control itself autonomously—looking for a grip-- but still takes commands from the central brain to clean the room in a random fashion or if the robot is floating away from the wall



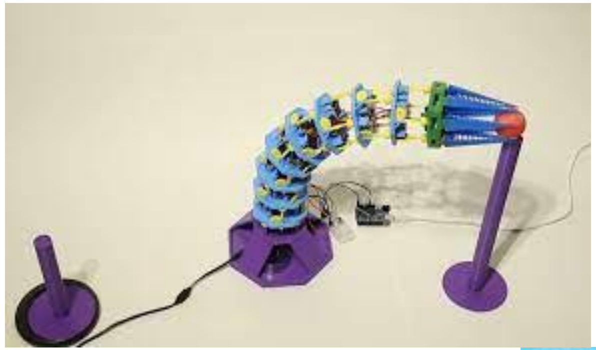
- No team should try to do a whole robot—each of these projects requires deeper thinking and prototyping. Two or more teams can put their projects together to help demonstrate how things fit together but that does not mean they will be selected together.
- Because this is the first attempt at this kind of motion, none of these have to act fast. This robot could take an hour to move a few inches. We need to see what kind of motion is possible

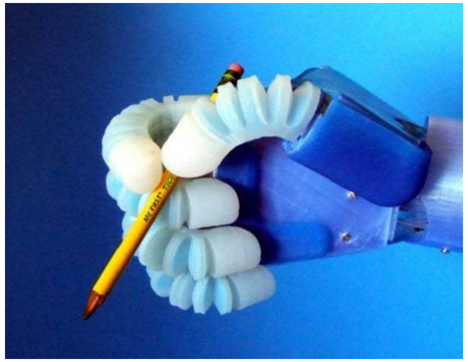
# General ideas updated to answer several good questions

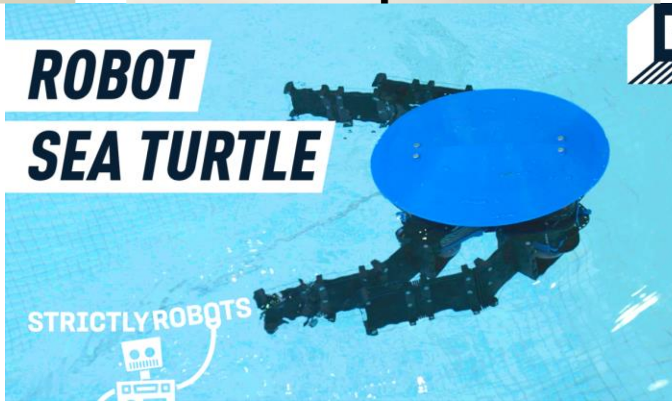
Nobody has done this before so we are exploring something new.

- As of now, we are attempting to demonstrate the technology and the techniques of how this can be done as individual parts.  I'm not too worried about the size of your demonstration as long as your prototype can fit on a table top and show how it works.  Once we have terrific ideas from each of the teams, then we will look at how to incorporate all of the ideas into a functional robot.
- The only team that needs to have motors at this point in the development is the control team.  If you are able to show your mobility arm or duster arm works by pulling strings or use a syringe to push air in and out of it, that works for me.  Later on we can see what kind of motor is needed to pull the string or pump to suck out the air. If you can activate your suction cup with a couple of strings and/or a syringe that will show the idea—motors are ok but not needed.
- This robot will eventually operate on batteries similar to a Roomba.  We would aim at it being able to operate for 1 to 2 hours on its own before it has to recharge.
- Expect that the internal temperature of the space stations will be around 71 degrees F.
- It needs to be soft so that it doesn't damage hardware as it moves around.  Also since we are aiming at many different space stations, soft robotics may allow for more diversity of movement in a generic environment.
- It is early to know what size the kwadropus duster will be in the end but I think we should aim for a robot that would be around 2 to 2 ½' in diameter and maybe a foot tall.

# Starting points but not enough information








**How does an elephant trunk work**

- https://www.businessinsider.com/elephant-trunk-powerful-nose-sniff-out-bombs-2019-1

**Anatomy of the tongue**

- https://www.google.com/search?q=how+do+tongues+move&rlz=1C1GCEA_enUS939US939&ei=-6YhZM3SFY7DqtsP5q6lgAY&ved=0ahUKEwiNvMPxp_z9AhWOoWoFHWZXCWAQ4dUDCBA&uact=5&oq=how+do+tongues+move&gs_lcp=Cgxnd3Mtd2l6LXNlcnAQAzIFCAAQgAQyCAgAEBYQHhAPMgYIABAWEB4yCAgAEBYQHhAPMgoIABAWEB4QDxAKMggIABAWEB4QDzIGCAAQFhAeMggIABAWEB4QDzIICAAQFhAeEA86CggAEEcQ1gQQsAM6BwgAEIoFEEM6CAgAEIoFEIYDSgQIQRgAUJsIWP0XYIYbaAFwAXgAgAGHAYgBnAeSAQMwLjiYAQCgAQHIAQjAAQE&sclient=gws-wiz-serp#fpstate=ive&vld=cid:aa384407,vid:lATWhP0wJ5c

**Robotic turtle—soft parts**

- https://mashable.com/video/mit-robot-sea-turtle

**Completely Soft Robot**

- https://www.technologyreview.com/2016/12/08/155290/meet-the-worlds-first-completely-soft-robot/

**Octopus soft arm**

- https://onlinelibrary.wiley.com/doi/full/10.1002/aisy.201900041
- https://www.youtube.com/watch?v=8IXncY4L_nc

**Chameleon inspired**

- https://www.youtube.com/watch?v=trDz4Ukz_VQ

**Langley Soft robotics lab**

- https://www.youtube.com/watch?v=VuxnPLU_KEs
- https://www.youtube.com/watch?v=iwQRYzLZvGE

**Oregami octopus—You will not be able to use magnets like this one because the changing magnetic field would damage the electrical systems in the space station, but there is some really cool thoughts here**

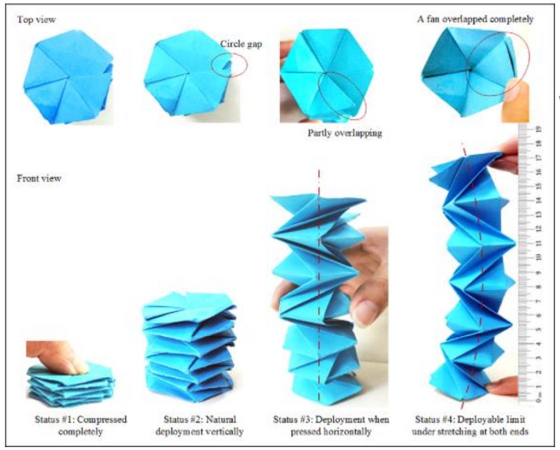
- https://techxplore.com/news/2021-08-omnidirectional-octopus-like-robot-arm-motor.html

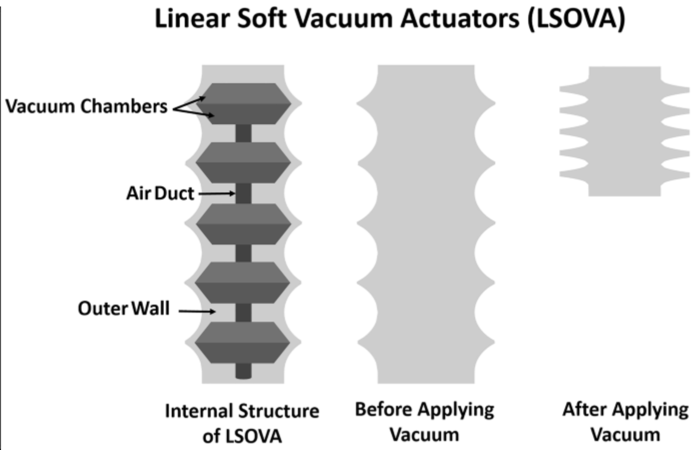
**Tips for making soft robotics components**

- https://www.youtube.com/watch?v=TyYW9BmMeSs
- https://www.youtube.com/watch?v=GgJt6vIbiso

**Other related ideas for soft robotics**

- https://www.universetoday.com/162514/engineers-design-a-robot-that-can-stick-to-crawl-along-and-sail-around-rubble-pile-asteroids/



# Duster Arm Team

Source of Dust

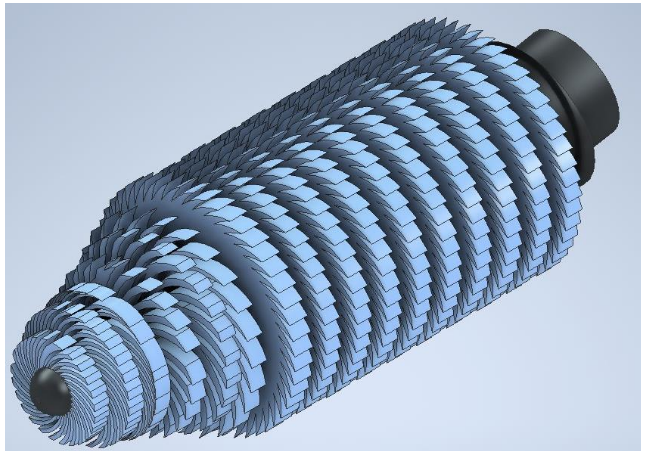
- Most equipment in a space station is made of aluminum and stainless steel and there are lots of cloth bags for holding supplies—mostly very clean environment. The dirtiest thing on a space station are the people. People shed skin cells and hair all the time. Mostly people don't notice on Earth because a lot of it falls on the floor and often gets pushed outside when the door opens. That never happens on a space station. On the ISS, there are also some mice used for experiments and they generate a significant amount of dust and floaties but they also have their own air cleaners and filters. There is some lint generated from clothing and cloth bags. Some also comes from food. In general the ISS is a clean place--if not for the people.
- We are trying to clean up the people dust and the dust from the clothes and bags. The duster arm of the Kwadrapus Robot will need to have something like a swiffer cloth attachment that will, in some kind of motion, collect dust from the wall of the space station. What kind of motion does the duster arm need to have? Combination of rotation, wiggle, twist,…?

**Requirements:**

- Duster will pick up dust without releasing it easily except when ready be cleaned.
- Maximize dust collection and minimize material needed to collect the dust
- Needs to be able to conform to changes in surfaces.
- Needs to be slow and a light touch to keep from pushing away from the wall and liberating dust into the air. We need something that will pick up the dust from the surfaces but not release the dust until the vacuum cleaner is used on it or it is thrown away or something similar.
- What kind of motion is needed to get maximum coverage while it cleans?
- How will the crew know to change out the duster pads? Just by sight?
- Although a Swiffer may be a good product, it requires a lot of resupply since each pad is removed when dirty and thrown away—that's a lot of up mass and volume to get rid of a little dust. How could we get more uses from a single Swiffer? Is there a more reusable alternative?
- Once it is full of dust, what does the astronaut do to clean it or remove it?







# Testing

The kind of dust will be a fine powder and some hair. The most relevant simulant is probably the dust that is under the bed, on ceiling fan blades, on top of the book shelf, in the back of the closet. For classroom purposes, a little talcum powder or starch may be a good practice material. Most important you are looking for a material and a motion that will hold as much dust onto the duster as possible. It seems like moving fast would throw dust instead of collect it. Slow motions seems like a good starting path but I don’t know if it means rotation, back and forth sweeping, undulations or combinations of many different motions. The next hard part is how the dust will be released from the rag/brush once it is full of dust.

- Do we throw away the whole duster rag/brush?
  - that’s more launch mass and stowage
- Do we clean it off with the vacuum cleaner?
  - how many times will that work?
  - how clean is clean?
- How much interaction does the astronaut need to have?
  - keep it simple and as short as possible

My Roomba takes way longer to clean my floor than if I were just get out the vacuum cleaner but it can do it when I’m not home or paying attention—save me time. We are trying to save the astronaut time even though it may take the Kwadropus more time.