Quieter fans

Problem:

There are lots of fans to move and mix air throughout the Station and also for cooling electrical equipment. Individually each fan is reasonably quiet; however, all of these fans in combination make a lot of noise especially because the station is a closed environment (aluminum tubes) that keeps most of the sound in. There are commercially available fans but not the right size and capability to match what is needed for the ISS.

Challenge:

Using existing knowledge from the internet on fans and blade technology, help develop fans that will make less noise but move the same amount of air or more. Model up new fan blades in CAD, print them in 3D printers and test them against a standard computer fan.

Old style propeller

New style propeller

Propellers and wings

- As airplanes got faster, engineers realized that the size and shape of the wing needed to change. Wings went from tear drop shaped cross section to much flatter and skinnier. They went from being strait out from the fuselage to swept back. This related to how much lift they needed for the speeds they were flying.
- Propellers on boats and on airplanes are the same as wings, whether they are in the air or in the water, they just rotate and push a fluid. So as propellers rotate faster or move more air or water, they also need to change.

Submarines

- When a propeller turns in the water, water is pushed equally by each blade. When the propeller exceeds a specific speed, bubbles are created on the blades and then collapse in the water column after leaving the blade. The creation and collapse of the bubbles causes sound and referred to as cavitation. This is unwanted noise if you are in a submarine. In the quest to develop quieter submarines, new propellers were designed that were different from other propellers. Instead of having 3 or 4 blades that were all the same, there might be 7 blades where each blade might be slightly different. One blade might be 5 ft long and a pitch of 10 degrees but the next blade might be 4.9 ft and have a pitch of 11 degrees and slightly wider to make up for the surface area lost to the length. The next blade might be 4.8 ft and 12 degrees. By making each blade slightly different but still push the same amount of water, cavitation was decreased or stopped. This made the new submarines quieter while underway than an older submarine tied up to the dock.

Old style

New style

Helicopters

- Some of the same techniques were later used on helicopters and airplane props but instead of cavitation in the water, they were working on cutting down the sound from the tips of the blades getting close to the speed of sound. Instead of having long straight blades with square ends, the new blades were slightly curved with more rounded tips. Some blades are wider close to the center and skinnier further out. Some helicopters have rear rotors where the blades do not all have the same spacing **<u>but they are still balanced</u>** to prevent them from flying apart when spun up. These techniques are for decreasing the sound but still giving the same amount of air flow for the same rotational speed.

- Drone designers are using similar techniques in developing their propeller blades.

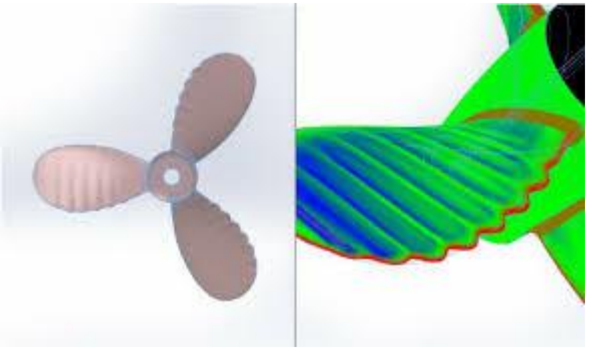
Things to look up

- Some blade manufactures are putting bumps on the front of the blades (tubercles) to effect the laminar flow over the surface. This idea came from the shape of the flippers on whales and is expected to decrease the friction of the air on the wing surface.

- These are just a few of the ideas and techniques that are driving the new wing and propeller designs happening today. Your first steps in this project is to study up on wings and look for technology that may help you get the quieter edge on the cooling fans. Once you

Fig 1:- Tubercles on pectoral flippers of the Humpback whale

(Source: THE PHYSICS OF TUBERCLE AIRFOIL AND THEIR APPLICATION TO WIND TURBINES)



THE CHALLENGE—<u>make this fan quieter</u>

http://www.sears.com/universal-parts-universal-bathroom-fan-replacement-exhaust-fan/p-SPM9774843422?sid=IDx20110310x00001i&gclid=EAIaIQobChMI8My1vM7I1gIVFLXACh29Ww-8EAkYASABEgK_ofD_BwE&gclsrc=aw.ds&dclid=CLKo7cnOyNYCFcehswodnqMJgQ#

- This is a generic fan commonly used for cooling or venting equipment at home that is cheap and easy to obtain. It is not used by NASA but the fan is easily changed out from the motor and its accessibility makes it so every school can get one. Mount this motor with the **smaller fan** and measure the sound coming off it. Some of the sound will come from the motor and some of the sound will come from the fan. Then design and print a fan that will mount to the same motor and measure the sound coming off your fan. Are they producing the same amount of air flow? Your first fan may be louder than the original fan—don't be discouraged, make some changes and try again. If your first fan is quieter than the original try to make it quieter with some other minor changes. Expect to make a couple of iterations before you get a quieter fan.
- Utility fan motor made to replace both C-Frame and 3 1/2" round styles of motors. 120 volts, 3000 RPM. The shaft measures 3/16" x 1 1/4", the stack size is 5/8".

TESTING

Good testing of your fan's sound qualities will need to be consistent from one fan to the next.

Many schools have sound measuring equipment in the physics class. You will probably need to ask around to borrow it for the testing phase. You might also ask the band teacher or the theater department who might have sound measuring equipment.

Place your fan in a PVC pipe and position the microphone in the center of the pipe 6" away from the front of the fan. The link below will give you an idea of how this should look. http://www.rotosub.com/s_products_demo.php

The purpose of this video is to demonstrate the testing. This one uses an active noise control system--we are not asking you for that. The pipe doesn't have to be transparent, PVC will work fine. The pipe also helps protect you in the event that your blades break apart for some reason. We only need sound readings from the down wind side.

Safety

- Safety—to prevent your fan from coming apart when rotating,
  - make your fan as one piece(no gluing or assembly)
  - solid print not hollow
  - Ensure that your fan is balanced before you spin it up on the motor so you don’t vibrate and damage your equipment.

Pointers:

- Look at existing computer fans, RC airplane blades, drone blades,
- Very slight changes in the shapes can have significant changes in the performance of the propeller.
- You might do a comparison between a blade strait out of the printer to one that has been sanded smooth. The ridges from the printer may have an effect on the air flow and sound qualities also.
- Consider having blades of different length and different pitch but all pushing the same amount of air.
- They also may not be symmetrically spaced around the axis but it would still need to be balanced.
- There may be bumps (tubercles) or vortex generators on the blades to change the turbulence across the blade’s surface.