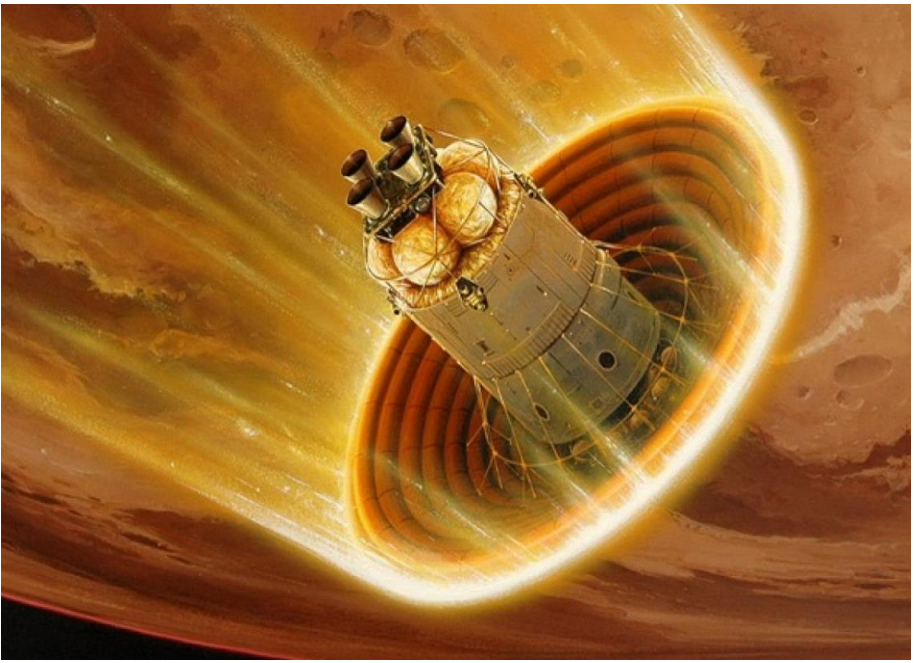
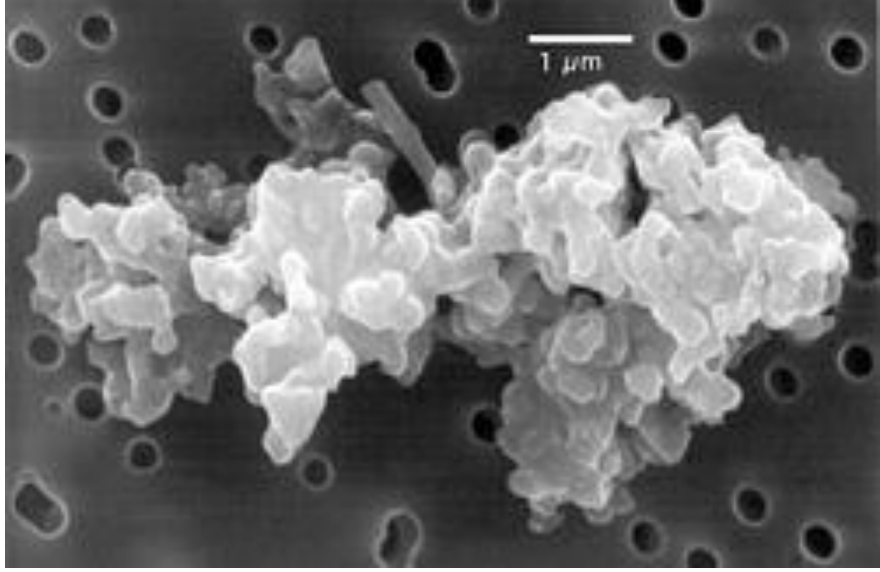
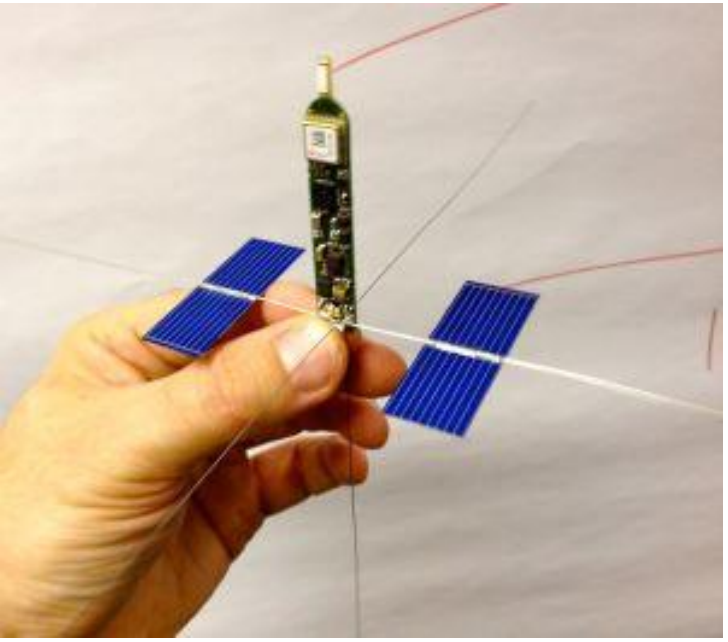


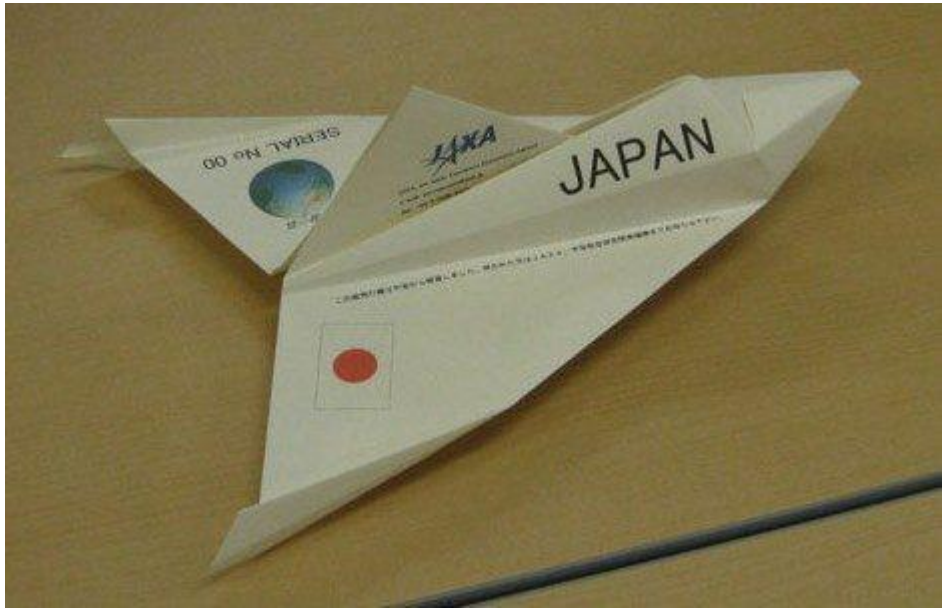


No Heat Shield

Glenn Johnson

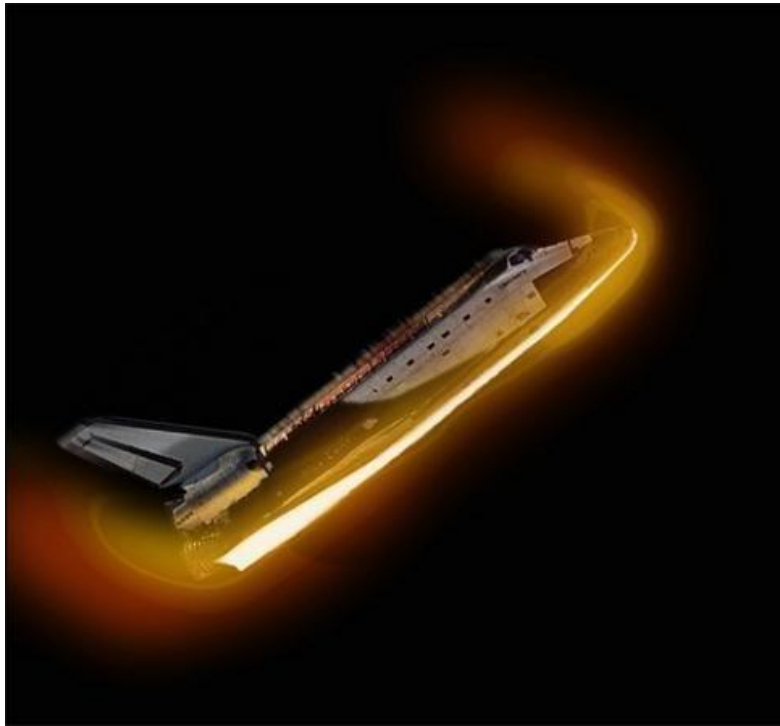


Develop a light weight, large area aero shape that can re-enter the atmosphere without a heat shield or burning up, that can be tracked while it is in orbit and while it is coming through the atmosphere but will probably be lost when it contacts the surface. This could be two separate groups.



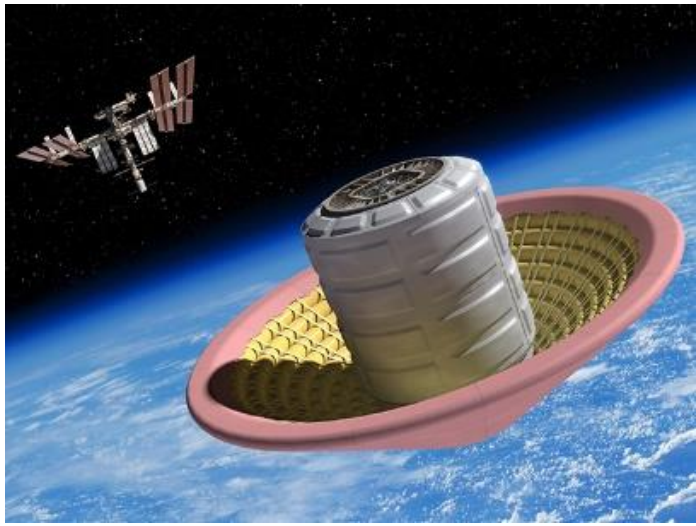
Background

When in orbit, a space craft is circling the Earth at around 17,500 miles per hour depending on the height of the orbit. Returning from space through Earth's atmosphere usually requires a heat shield to protect the occupants from the excessive temperatures generated as the friction of the air particles slow down the space craft. Most space craft use an ablative heat shield that flakes away as the material gets hot and carries away the heat with the little flakes. The Space Shuttle had insulating tiles that could handle the heat and prevented the heat from transferring through to the inside of the ship. All of these ships and space craft had a lot of mass and a lot of momentum that made it difficult to slow them down from orbital speed.

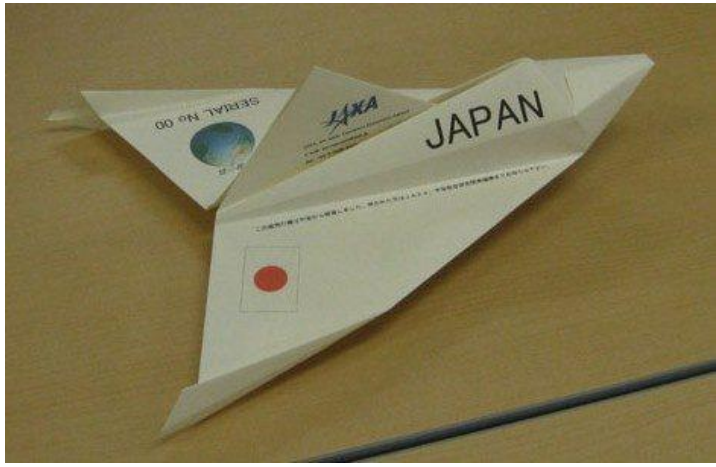


Thought problem

- Imagine if you had a very low mass space craft but a large surface area, it would take a smaller amount of force to slow it down. The less mass, the less force to slow its velocity. The larger the surface area, the greater the effect of the air friction. This is also how the inflatable air shield worked that was tested a few years ago.
- Several years ago Japanese researcher Dr. Shinji Suzuki suggested that a JAXA astronaut Koichi Wakata release 30 paper airplanes from the International Space Station and let them re-enter the Earth's atmosphere and expected that they would make it to the ground without burning up as they slowed down. Dr. Suzuki even demonstrated that one of the paper airplanes could survive a Mach 7 wind tunnel with minimal damage. Any one of the released paper airplanes would only have a 30% chance of landing on the ground since most of our planet is covered with water. But if one was found in a populated area, they had a phone number and address that would allow a person to contact the space agency to claim a prize. Someone must have thought the odds were too low for success out of the experiment so the airplanes were never released.
- https://www.airspacemag.com/space/the-ultimate-paper-airplane-51433308/
- http://www.nbcnews.com/id/23827045/ns/technology_and_science-space/t/paper-airplane-fly-space-earth/#.XMNYojZYahc

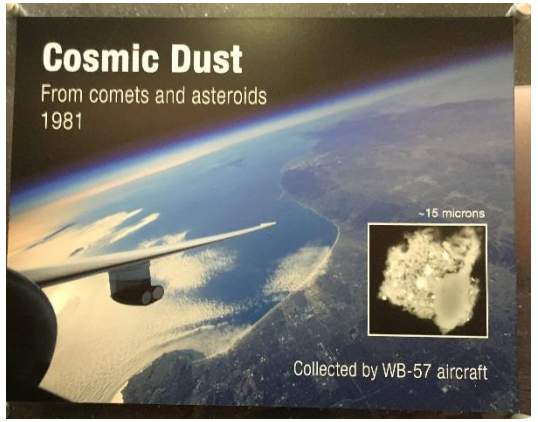


Inflatable air Shield



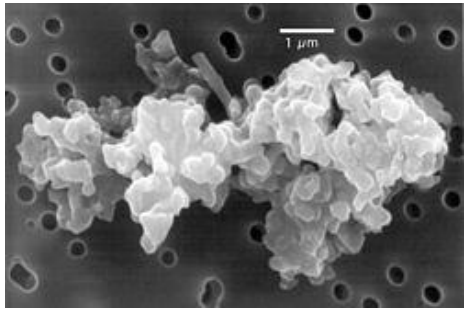
JAXA origami airplane

Captured in Atmosphere



Supporting research:

- NASA has been collecting cosmic dust that falls through the atmosphere since the 1980's. The NASA WB-57 and the ER-2 high flying aircraft have flown with sticky material on retractable surfaces of the plane and has returned pieces of cosmic dust stuck to the sticky surface. This is proof that it is already possible with very tiny, light weight particles and relatively large surface area to come through the atmosphere without burning up.



- https://www.stripes.com/news/nasa-plane-collects-dust-really-tiny-cosmic-dust-1.39530
- https://curator.jsc.nasa.gov/dust/
- https://www.wired.com/2012/08/nasa-perseid-meteor-flights/
- http://www.elementsmagazine.org/archives/e12_3/e12_3_dep_cosmoelements.pdf
- I am certain that there will be skepticism about whether this will work. The whole argument should center on the amount of frictional force from the air it will take to change the velocity of the 'satellite' as it comes through the atmosphere. Imagine a canon shooting confetti. Even though the gun powder might make it exit the muzzle at Mach 1, the paper pieces would slow down quickly and fall to the ground. Even though a bullet or canon ball may get hot from the air friction as it travels through the air, the paper pieces might only be singed from the ignition of the gun powder because it takes so little frictional force to slow them down.
- Despite the paper airplane experiment not occurring, I am convinced it is still a great idea but I would like better odds of getting real data for an orbital speed payload returning to the ground without a heat shield.

No heat shield page 4

Problem:

- Develop an air foil that would allow a 200 gram electronic package (battery included) to be slowed down by the atmosphere without burning up.
- Develop an electronic payload that would allow tracking and maybe data acquisition from the time of release to the time it might land (could be a long time--like a year or more).
- This package should utilize ham radio frequency 437MHz to send a ping on a regular basis so it can be tracked easily from the ground.
- Sunlight sensor could help to only send a signal when it is getting power from the sun
- NORAD can track some items in space depending on the cross sectional area and reflectance
- 437 MHz---Antenna size—6.42”
- Tips: consider
  - a maple tree seed pod and how it helicopters down to the ground
  - Different paper airplane designs
  - Toys that fly and flutter to the ground
  - What kind of materials would you use?
  - How big of an object can NORAD track in space? Would they be willing to assist with tracking? It will have a different visiblity in different orientations.
  - Assume that it may be deployed similar to how the Lightsail 2 was deployed from the second stage of a rocket.
  - https://www.theverge.com/2019/7/7/20683623/lightsail-bill-nye-planetary-society-satellite-earth-update

- Suggested teams:

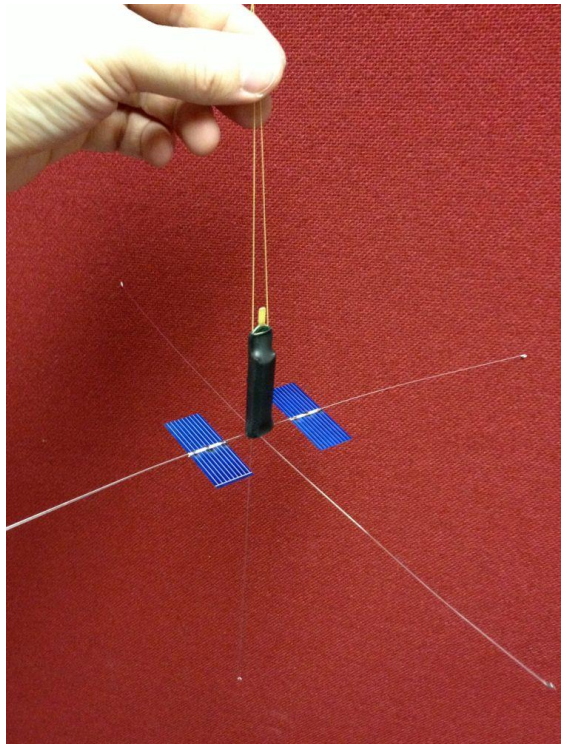
2-3 people developing the air foil and materials, 2-3 people developing the electronics package, 2 people developing the power, need someone with a ham radio license—not very difficult.

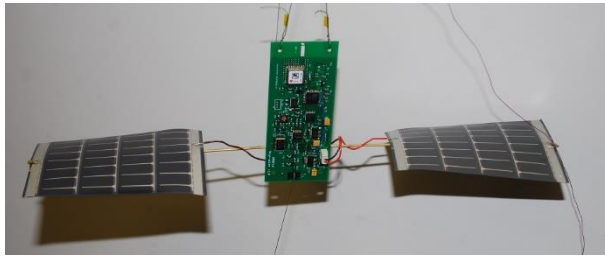
Application:

- If we proved this could work on Earth, would this be a viable method of dropping many small probes to the surface of Mars without heat shields and scattering them over a large segment of the planet and retrieving lots of data points from many locations?
- Could this be a way of getting high altitude atmospheric data from the region between a space craft orbit and the high altitude balloons since there may be significant linger time in the upper regions?

Electronics package

- The most important information is where the satellite is and if it is still functioning. Since we don't know how long it will stay in space, the biggest difficulty is powering the transmitter that tells us it is alive. Could this be done with solar panels or do you need a battery pack? If it is easy to get more information without costing more mass, do it. If not, don't bother.
- Here are some websites of people using small balloons and small radio transmitters to do similar things. There are some small balloons that have gone around the planet 7 times.
- https://amsat-uk.org/2014/07/30/434-mhz-balloon-goes-around-the-world/
- http://www.aprs.org/balloons.html
- https://gmigliarini.wixsite.com/wb8elk





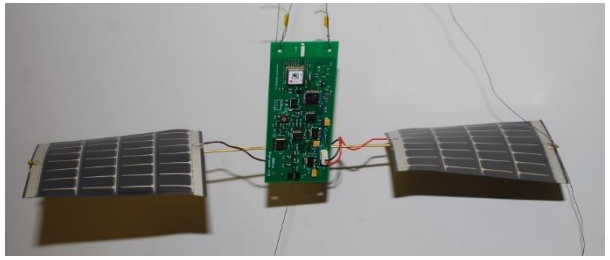
Thoughts on testing

- Place your electronics in the freezer and see how it works.
- Place your electronics in a vacuum jar and see how it functions. Is it able to dissipate its own heat over time? Are any of the components damaged by the vacuum?
- Drop your project from a high tower or building. Is it able to slow the package down enough to not be damaged?
- Lift your project with a drone over a big field and drop your project from the drone's highest elevation. How long does it drop before there is enough force from the air surface to start slowing it down? What happens with different orientations when dropped?
- There are a few schools who may be able to drop their project from a weather balloon. Some of these balloons can go as high as 100,000 feet where the air is very thin and the project would reach at least Mach 1 as it begins to fall. This would be a good test to see how both the airfoil and the electronics behave in the near vacuum of that altitude—temperature, radiation, air pressure. Although dropping from the balloon is a great beginning for testing it in space, it still doesn't test how it will behave at re-entering the atmosphere at 17,500 mph. The only way I can think of testing this is to put it at the top of a rocket. I'm not sure how we will get some of these designs on top of a rocket yet but I am working this one step at a time.
- I expect some of you may have some better ideas and methods of testing. Try them!

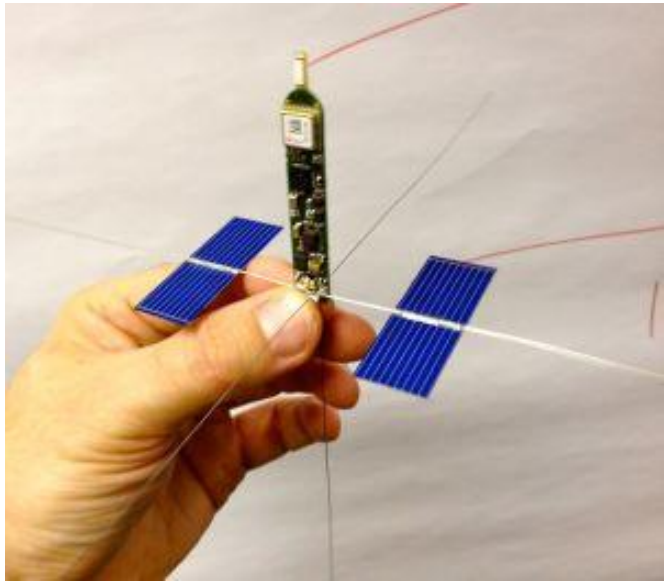
- I talked to Jim Langsted from Edge Of Space Science (EOSS). He is part of a non-profit organization that sends up high altitude weather balloons several times a year. I told him about the No Heat Shield project and he was very interested in what the students were doing. EOSS is a team of volunteers that has the permits to buy, launch and track the balloons by car and with ham radio as they travel across a couple of states. They do more balloons than anyone else in the country (maybe world I can't remember). This is not a free service as these guys need gas money and balloons are not free but this may be within a budget that a school can afford. Although they are based out of Denver, they do projects for students from many states. They would love to hear from any team. There are some difficulties that we will need to work through. Normally they are only dropping the package attached to the balloon—one object. To drop something separate from the balloon from 100,000 feet we will need to get some permits from the FAA. It may depend on the type of object being dropped so I don't have specifics yet. If you are interested in taking your idea to the step closest to space use the link below to learn what it will take to get it to the edge of space.
- https://www.eoss.org/

Existing micro balloon transmitters

- http://www.aprs.org/balloons.html



- https://amsat-uk.org/2013/10/12/437-700-mhz-ham-radio-balloon-heading-for-uk/



Ham radio help

- This may require at least one of your team to get their ham radio operators license. This is not difficult or expensive and can be done on your computer from home. It also looks good on a resume.
- It may also be helpful to contact a local ham radio operator and ask for help or advice. You may already know someone that has their license. Some of the operators have lots of experience with different radios. They may be interested in help out with finding transmitters and how to set up the kind of circuits needed. Do a google search for **Ham radio operator near me**
- There are also clubs who might be interested in being involved. If your project flies, you will want lots of clubs to be involved around the world to help track as it orbits and as it descends into the atmosphere.
- You can schedule with your school to talk to the astronauts through your ham radio while they are on the Space Station. On occasion the astronauts have also talked with schools through their ham radios for practice during training sessions. Ken Ransom is the main ham radio specialists for the space station who helped me out with this project. https://www.ariss.org/contact-the-iss.html
- HUNCH also helped ARISS out with a 3-D printed cover for some of their hardware.

Questions from Last year's students

- 1) Do the forces of aerodynamics apply to an object in space? If there isn't any air, the aerodynamics forces will be either negligible or nonexistent. A paper airplane in space will just tumble until it meets up with some air. Paper air planes also depend on gravity to pull them down to make them go forward. You can watch one of the astronauts throw a paper airplane on the ISS on youtube and the plane just tumbles.
- 2) How can we make an object fall in a specific orientation? After your object starts coming back into the atmosphere, the aerodynamic forces will increase. At first your object will do some tumbling but should orient itself according to how you have constructed it.
- 3) What form does our electronic package have to be in? Are there any specifications other than that constraints discussed on the project PDF? You may configure it in any fashion you want. The main thing you should be interested in is being able to track the location but it may cost very little in mass to add other capabilities like temperature probes or accelerometers. I was just talking to Jim Langsted from Edge of Space Science who flies many high altitude balloons for student projects. He was talking about the difficulties about how some batteries don't work in low temperatures.
- 4) How can we create drag in a vacuum? I don't expect you can. The space shuttle didn't use its wings until it came back into the atmosphere. The International Space Station has to be boosted up into a higher orbit about every month because the very thin amount of air that it travels through slows it down just a tiny bit every day. This happens to all satellites—more when they are closer to Earth and less for those that are in higher orbits. More for bigger satellites and less for smaller ones. Whatever your experiment looks like when it gets on orbit, it will be slowed down by the atmosphere and fall back to Earth at some point—it might be a very long time depending on its surface area and its mass but it will come back.