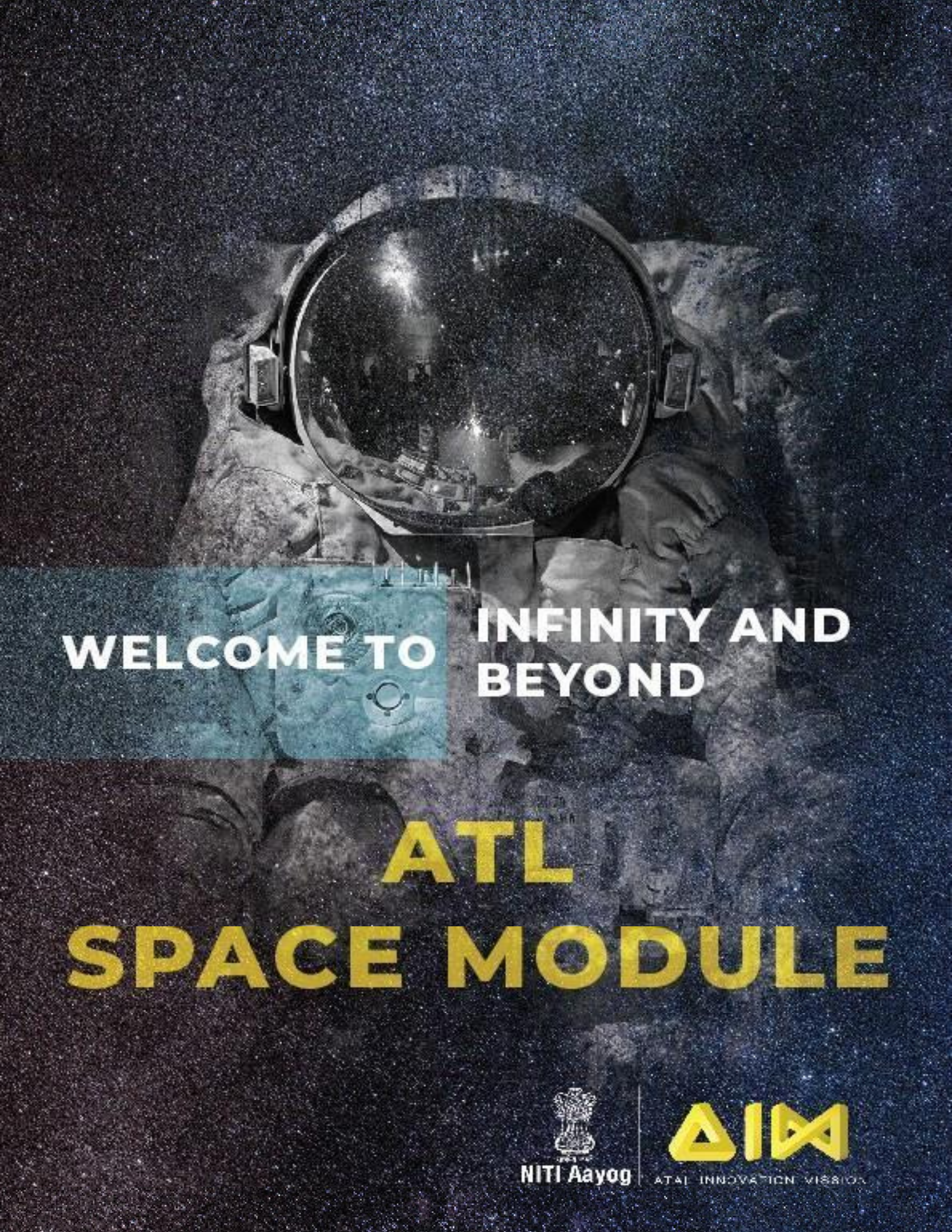

WELCOME TO INFINITY AND BEYOND

ATL SPACE MODULE

NITI Aayog

ATAL INNOVATION MISSION

“Atal Tinkering labs will allow you to convert your imaginations into incredible innovations giving birth to potential job creators.”

Ramanan Ramanathan
Mission Director, Atal Innovation Mission
NITI Aayog
Govt. of India

FOREWORD

Science and technology form the foundation for a country's economic growth and development. With 50% of Indian population under 25 years of age, India's way forward is to empower her young children with latest technologies. In an attempt to rejuvenate the Science and Technology innovation wave in India, the Govt. of India has launched Atal Tinkering Labs, a flagship program of the Prime Minister of India, under the aegis of Atal Innovation Mission, NITI Aayog, Govt. of India, with an objective to create young innovators and entrepreneurs. The idea is to allow children to explore the world of research and innovation, and contribute towards nation development, by developing innovative and disruptive solutions to India's biggest community problems.

In this regard, Atal Innovation Mission, NITI Aayog is pleased to launch the ATL Space Module this summer of 2018, to motivate students to explore and demystify the world beyond the earth. The ATL Space Module will allow student innovators to understand the technologies that are used in space, to get inspired. The module is a starter's kit to Space science, developed on the philosophy of 'learning by doing'. Students can build their own prototypes with the help of introductory information provided in the module.

Happy Tinkering with Infinity and beyond ☺

Dr. Ayesha Chaudhary
Atal Innovation Mission
NITI Aayog
Govt. of India

ACKNOWLEDGEMENT

We would like to thank Dr. Danielle Wood, Massachusetts Institute of Technology - Media Lab, Cambridge, USA for her help and guidance in creating this module.

DISCLAIMER: The content in this handbook has been curated from various online sources. We do not intend to infringe on any copyrights.

Contents

Introduction

What follows is a set of activities, ranging from the simple to the more technical. These are expected to make you think about the earth around us, space and how we are exploring this final frontier for mankind. The activities mentioned here are very open-ended exercises, where step by step instructions are NOT given. You are instead suggested to design something and are told about its function and working very briefly. You are encouraged to explore the activities given here on the Internet and see if you can add to them & make them more challenging and simulating. While doing these activities, keep in mind how things you are simulating on this small scale are done in real-life. Explore how the real-life versions of these devices work and how can you improve upon those using what you learned when doing these activities

Walkie – Talkie

In space, no one can hear you scream! And as scary as that sounds it shouldn't frighten you, because if you can understand why something is the way it is then there's no need to fear it. Sound waves travel through the air due to the vibrations caused in the air particles, but without any air, sound will be unable to travel across the spectrum! These kinds of vibrations have another name: longitudinal waves. In fact, there are two main types of waves: transverse and longitudinal.

Radio waves are an extremely important aspect of this spectrum. Radio waves are a form of energy and thus, they travel at the speed of light, and the further the signal must travel, the more power you need to send and receive the signal. This is the key information that designers use while building antennas. On earth we use our cell phones to transmit radio waves via cell towers, similarly in space we use satellites to transmit radio waves and facilitate communication, but they must send signal much further over hundreds of kilometers. Can you think of any other instances where radio waves are used?

How does sound travel? Does it require a medium? If so, what type of medium is best for sound to travel through?

Image Source: FreeImages.com/Per Hardestam

Having thought about these questions can you design a simple communication device which can be used to send a message across 6 meters or more? One design is shown in the image below. Can you think of some other design for carrying out this task?

What question do you need to answer to design this type of device? What material of cups would give you the best results? What material should the connecting line be? Experiment with different materials to find which would give you the best result. Use the internet to find out more about this type of device and how it works.

Advanced Activity – the wireless walkie-talkie

- Using the Electronics Development, Robotics, Internet of Things and Sensors Package-1 of your ATL, can you make a wireless walkie talkie? You can use the RF Modules Tx & Rx 315 MHz ASK from the package. What else will you require? Use the internet to find the relevant circuit diagrams to make your very own wireless walkie talkie.

Telescope

Have you ever looked up at the stars at night and wondered how far they are? Well, they're millions of miles away and the reason we can see these stars in the night sky is because the light that's produced by these stars travelled millions of miles to arrive at our eyes. So, some stars that you can see now may not even exist anymore. The reason our eyes can see an object is because our eyes work like a lens, somewhat like a pinhole camera that you will read about later. So, the image falls on the retina and thus, you can see it. Are there any other reasons why we can say our eyes are the perfect lens?

Image Source: unsplash.com/Drew Coffman

Telescopes are used to view far away objects with better clarity. The key components of a telescope are the lenses or the mirrors which capture the light and focus it for you to see.

To make a distant object appear brighter and larger, we effectively need a bigger eye to collect more light. With more light we can create a brighter image, we can then magnify the image so that it takes up more space on our retina.

The big lens in the telescope (objective lens) collects much more light than your eye can from a distant object and focuses the light to a point (the focal point) inside the telescope.

A smaller lens (eyepiece lens) takes the bright light from the focal point and magnifies it so that it uses more of your retina.

A telescope's ability to collect light depends on the size of the objective lens, which is used to gather and focus light from a narrow region of sky.

The eyepiece magnifies the light collected by the objective lens, like a magnifying glass magnifies words on a page. But the performance of a telescope depends almost entirely on the size of the objective lens, sometimes called the aperture.

Would you be able to build a simple home-made telescope with lenses and simple stationery items like cardboard, glue, tape etc.?? You could search the Internet on how to make one or for the additional challenge you could forge on your own and come up with your unique design.

Note: Different types of telescopes can see different kinds of energy on the electromagnetic spectrum. Can you name a few?

Convex & Concave Lenses

You would have studied about the behaviour and properties of lenses like focal length, etc. in your physics class. Some questions to ponder when you are building you own telescope.

- What type of lens should you place in-front and which type would be your eye-piece?
- What should be the distance between the 2 lenses for the best image quality?
- What property of the lens would control the magnification of your telescope?

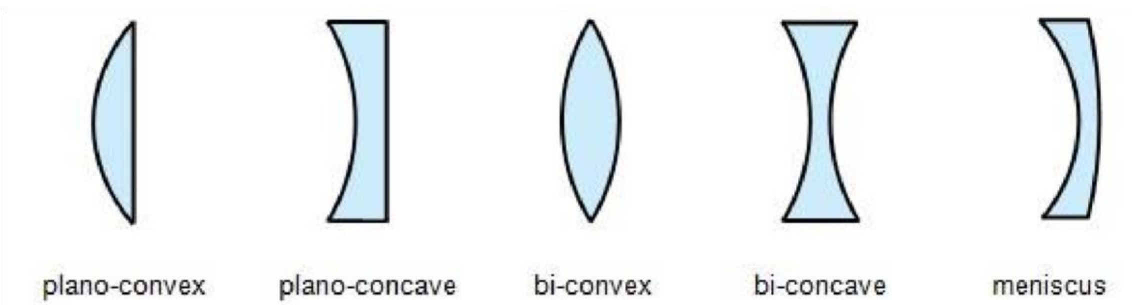

Image Source: Ramya J.S./CC-BY-SA-4.0

Happy Tinkering on your telescope and always remember – be very careful and never use your telescope to look directly at a bright light source like the Sun. You can use your telescope to explore the night sky and see if you can identify the major stars and constellations.

Pinhole Camera

A pinhole camera is a very simple device which does not have any lens or mirrors but a very tiny aperture (a pinhole) – it is essentially a lightproof box with a hole in one side.

Light enters the box through the tiny pinhole on one side and strikes the opposite wall of the box, where an inverted image is formed. A light sensitive paper or even photographic film placed here can record the image.

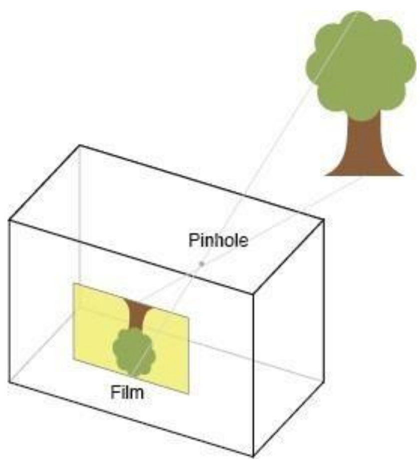

Image Source: Kyle Simek/CC BY-NC-SA 3.0

A pinhole camera, which is simple to make out of ordinary materials and using ordinary photographic film, can be placed anywhere and left for several minutes to record whatever photons enter it. It can be placed in dim light or nearly in the dark, and, if left open long enough, will record an impression of all that goes on in its field of view.

Why don't you try to make your own pin hole camera? A quick search on the internet will show you numerous methods to make one using easy to get materials. Maybe you can improve upon these designs to make your own great prototype.

Glove Specimen Box

Do you know how do scientists work with materials which could be dangerous or could get contaminated by direct human contact? When the Apollo missions to the moon returned with rock samples, extra care had to be taken during their analysis to make sure that they did not get adulterated by the earth environment.

A simple device used to isolate specimens and study them is a glove specimen box.

Image Source: NASA

This device keeps a specimen isolated from the surrounding environment and yet allows scientists to handle and work with it.

Now can you make a simple glove isolation box to work with any samples that you may collect?

- What items will you use?
- Since any sample that must be kept safe from contamination will be sealed when you first get it, think how will you put it in the isolation box for the first time?

Rover

Space agencies around the world have landed rovers on the Moon and Mars. The later Apollo missions to the moon took with them a rover which they drove around the lunar surface. We have managed to land probes on other bodies like Venus also, but these don't have wheels/tracks to explore away from their landing sites. Recently in 2012, NASA's Curiosity Rover landed on the Red Planet and sent back aweinspiring pictures and a plethora of scientific data.

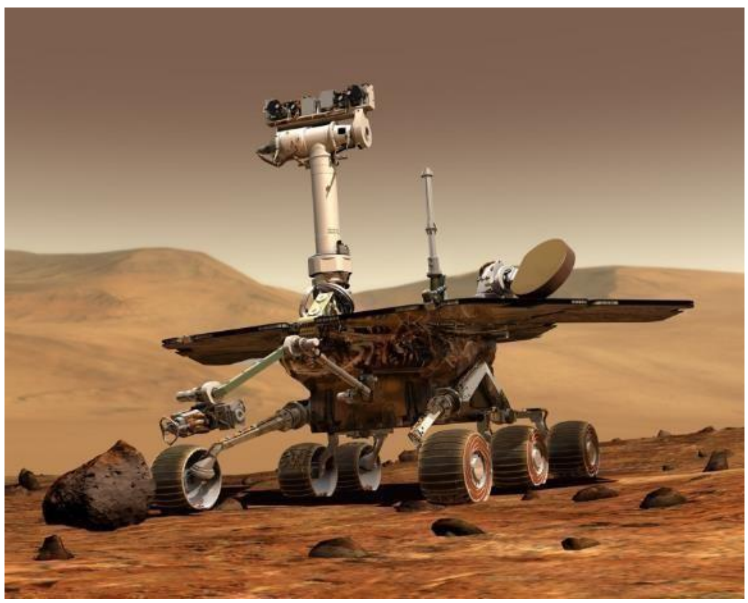

Image Source: NASA

Since you would have made various kinds of robots in the ATL till now so why don't you make your own rover to explore your surroundings. Remember that your rover can be autonomous, or you can remote control it.

Rovers sent to other world generally have the ability to collect soil and rock samples. Can you design your rover to collect these samples and then deposit them in the glove specimen box that you might have made earlier for you to analyse?

Advance Activities

- Can you design your rover to be manned? To simulate a manned mission, use an egg as the daring explorer. Now your rover must be designed in such a manner that the egg does not break no matter what the obstacle that the rover must cross.
- Can you make your rover completely autonomous? It should be able to go to a specific site, extract a soil/rock sample, store it safely and return to its start spot. Can you design it to deposit the specimen in your glove specimen box automatically?

Weather Vane & Anemometer/Wind Speedometer

A weather vane, also known as a wind vane is a simple device which tells us the direction that the wind is blowing.

All it consists of is an arrow (or an ornamental shape, for e.g. a rooster) mounted on a central axis in such a manner that it can rotate freely about it.
The image below shows a traditional wind vane.

Image Source: Nevit Dilmen/CC-BY-SA-3.0

So, can you make one, using only simple stationary items?

The wind vane that you make, will tell you the wind direction. How can you find the wind speed? The device that measures wind speed is called an anemometer.

While there are many types of anemometers, working on different principles, the simplest design consists of 3 - 4 cup shaped surfaces mounted on horizontal arms, and the entire setup mounted on a vertical shaft, free to rotate. Wind blowing on the cups makes the system rotate with a speed proportional to the wind speed. So, the rotation of the cups over a fixed period of time is directly related to the wind speed. All that is needed is to calibrate the device, so that you know what rotation speed of the cups is equal to what wind speed.

Image Source: Arjuncm3/CC-BY-SA-3.0

So, how would you make your own anemometer? Again, many different ways are possible. Think about an electric fan, when we supply voltage, it rotates. Inverting this process, if wind moves the fan, an electric voltage is generated, and this is proportional to the speed of the fan rotating. Can you use this principle and maybe a simple computer fan to make you own anemometer?

Why is measuring wind speed and direction important? You will soon find out in the following activities.

Mini - Satellites

In Feb 2017, the Indian Space Research Organization launched a record breaking 104 nano-satellites, all on board a single rocket.

Satellites, which are used for several things ranging from communications, weather forecasting to further space exploration must be as small in size and weight as possible. This is because it is very expensive to launch heavier objects into the Earth's orbit. While companies like Space-X are working to reduce these costs (with concepts like reusable rockets), as of now the heavier your satellite, the more money you need to get it into orbit.

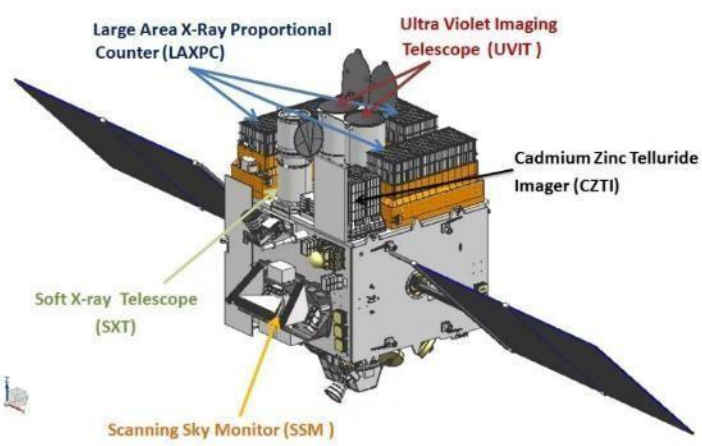

Image Source: ISRO

To understand this challenge and other challenges faced in the making of a satellite, why don't you make a mini-satellite yourself?

Your satellite dimensions should be around 150mm x 150mm x 150mm You can make it bigger, but remember that in the real world, a larger satellite means more launch costs. The same goes for weight, you want to keep your satellite weight as low as possible, preferably around than 350 - 500 gm.

Now, your mini-satellite would need to have a power source and a controller, that is obvious. What else can you put on your mSat?

Suggested Sensors for your Satellite

From the ATL Package - 1

- Triple Axis Magnetometer
- Humidity sensor
- Triple Axis accelerometer
- CMOS IR Camera Module - 728x488 – to take awesome pictures
- RF Modules Tx & Rx 315 MHz ASK – to communicate with your mSat after launch.

Apart from these what additional sensors can you put on your minisatellite?

You can put one or all these items on your mSat, feel free to add anything else that you feel might add value to your mSat mission, maybe solar panels for power supply? Just remember that too much weight and there will be launch problems.

Well since we are not covering rocket science in this module, so now how do you launch your mSat after having made it and having overcome all those size and weight challenges?

Solution – Helium Balloons. You would have seen these balloons at birthday parties floating on the roof. As Helium is lighter than air, it floats, and helium balloons have some lift capacity. Now, how many balloons you will need to lift your mSat depends on how much weight you put in it. See why we were telling you to be cautious about your mSat's weight?? So, optimize your design and launch your mSats!!!

Remember to tie a string to you mSat to recover it. Look at the data you collect through the various sensors. What does it tell you?

Advanced Activities – From satellites to spacecraft

- Satellites were the precursors to manned human space flights. Can you extend your satellite design into a manned space capsule? Use an egg to simulate the brave astronaut and see if you can recover him/her safely after a launch.
- One of the more futuristic methods envisaged by scientists to propel spacecrafts is the solar sail. It is supposed to catch the "solar wind" – the stream of charged particles from the Sun's upper atmosphere and use it to propel the craft. Can you design a model of such a solar sail for your mSat. Remember the solar sail must be stored safely till the satellite clears the earth's atmosphere and

reaches outer space. There it will open to its full size and allow the satellite to coast on the solar winds. Similarly, your solar sail will have to be stored safely with the mSat yet be deploy-able when needed. Read up on solar sails on the Internet and decide what material and design would be best for you.

Mission Control

Space Missions of any type – satellite, rovers or manned are all directed from Earth by Mission Control, a group of experts who monitor all the data coming from the spacecraft and direct and guide it.

Since you are going to be running two separate missions – the mSat and the Rover, build a mission control panel for communicating and controlling these missions.

Image Source: NASA

Use LEDs, LCD displays, buttons, etc. to make your very own mission control. You could remote pilot your rover through this or view the images being sent by your mSat.

Or if you are up to the challenge, you could run both the missions at the same time through the mission control. The possibilities are endless. Try to see how you can combine all the things that you have done so far.

HAPPY TINKERING ☺

सत्यमेव जयते

NITI Aayog

ATAL INNOVATION MISSION