Space Debris and Its Solution

Aahan Karnavat

Humans have now begun to explore the realms of the universe, or, the multiverse. Future locations for humans to call home, finding planets which tell more about our enigmatic past, and countless other aims are what scientists are focusing on. To get to the iota of things, space missions are widely used. The Indian Space Research Organisation alone has carried out 123 space missions and 82 launch missions1. With space explorations on the rise, scientists are continually discovering new secrets of our solar system. Space missions are not easy to carry out. It takes months of dedicated planning and hard work to get the mission up and running. The costs too are a constraint. It is not possible to spend millions of dollars on every space mission. Due to this reason and the efforts behind it, if any mission fails, the organization becomes crestfallen. If there is a major loophole in the space craft, then scientists can still understand the fact, but missions failing because of few centimeters of steel? That is completely inacceptable. This is the rising problem, that if not countered can become as huge as global warming is now. There are over 128 million pieces of debris under 1 cm orbiting right now2. These high velocities pieces can be the factor between success and failure. These small infamous pieces are known as Space Debris.

I. Space missions

The race to space, as its popularly known, is getting more intense. All countries are trying to become space superpowers by launching multiple missions and being the first to uncover something. Missions to: moon, mars and other places of the galaxy are being executed and newer ones thought of. Although the costs of space missions have been reducing, they still are in billions. That is a major reason why scientists can't afford to make any errors. The intricate designing and details mean months of patience cand determination goes into making the machines ready for their purpose. Successful missions have found out more about the moon, black holes, spectacles of black hole taking in something big, collisions between black hole and a neutron star, seeing the brightest light and what not.3 Human kind has learned more about the past only through these explorations, hence they play such a vital role in the progress of mankind. Every space missions focus has always been results. That is where we humans are making a mistake.

II. How space missions end?

Nobody really focuses on how space missions actually end; or what happens to the shuttles once their purpose is served. The truth is quite puzzling. Until SpaceX's recent revolution, all space missions ended in a grand but abysmal manner. The most common ending would be the space shuttles or rockets exploding themselves! There have been instances when shuttles crash into other planets like the rings of Saturn to destroy itself.

This is a popular practice which has been used for many years. The reason why this kind of waste has been neglected is because the common man cannot see it. The waste is in the space so organisations don't really worry about it. A Chinese space mission increased the trackable waste by 25% alone. These are staggering facts which if not done something can be a big problem mankind has to counter. The waste in space is known as space debris.

III. What is space debris?

Space debris is defined as all non-functional , defunctted , human-made objects, including fragments in Earth orbit or re-entering into Earth's atmosphere. This is basically left over of failed missions, rockets whose purpose has been served etc. The space debris are of various sizes: from a few millimeters to more than a meter. However, the size won't make a difference as even the smallest of pieces can damage shuttles and lead to the withdrawal of manned or unmanned missions. The amount of space debris accumulating is increasing each year. The debris forms a layer over the atmosphere which basically obstructs the smooth flow of rockets and can lead to mission failures. Nobody can plan for these problems as they are oblivious to us.

IV. How does the debris harm us?

There are innumerous ways the space debris can harm us. As iterated above, rockets and shuttles can be damaged due to it. Satellites that are orbiting earth can also be affected due to the fragments. Thus, leading to communication problems on earth.

If the debris is in the Lower Earth Orbit (LEO) , then the probability of it falling back down to the

[1] All Missions - ISRO

[2] ESA - Space debris by the numbers

[3] 26 Mind-Blowing Discoveries and Breakthroughs in Space in 2019 (businessinsider.com)

earth is also very high. This means humans can be harmed by the debris and can also lead to damage of buildings etc. Sometimes , missions are planned in such a way that the rockets would explode and fall back into the ocean. This is a major issue as the ocean gets polluted in extremely harmful ways. The fuel of the rockets , sharp small pieces, and other parts likes wires can cause adverse effects to the marine life. A simple example being fishes consuming the small parts like wires assuming it to be some kind of food and then leading to their illness. Furthermore, the International Space Station has also been damaged on many occasions due the space debris. There is also a 'hidden cost' which many people are unaware of. Firms cannot predict the nature of the debris hence any damage done to the spacecraft by the debris is needed to be repaired which is the additional cost. The reason it known as 'hidden cost' as it is unknown to the firms how much the cost will be. It can range from being too much, too just a minimal amount. Moreover, once a rocket has been abandoned, there can be some fuel left in the fuel tank. Over time there can be mixing of fuel components which can further trigger self-ignition. This undoubtedly increases the number of debris but also reduces the size and makes the junk orbit at high velocities, again becoming a threat to other missions. The high velocities are the important factor due to which the debris is so dangerous.

V. Reducing the debris

There are a few ways of reducing the space debris. The most common one is to make rockets which can serve a longer duration. This increases efficiency and reduces the space debris being accumulated. A rocket has many energy sources. After it has been used the leftover energy sources can be an issue. The energy sources are vulnerable to self-ignition, as mentioned above. Therefore, an energy dissipating system should be in place for prevention of damage. Batteries are present in spacecrafts and are an important energy source. So, a battery management system can be developed to ensure the batteries are discharged in the end. One more of the methods to reduce space debris may sound a bit naïve , but it a fact in reality. There have been instances of spacecrafts colliding with each other in outer space.4 It also common for satellites to collide with space debris. Hence Collision Avoidance Techniques should be in place. This includes sensing if any other crafts are around. Also avoiding spacecrafts to travel in crowded orbital regions will prevent damages .

These are just few of the methods we can use to prevent space debris from being created. However, prevention can't be the way forward as this is just delaying the final outcome. There has to be a system or a way of eliminating all the space debris.

VI. Existing methods to remove space debris

Leading space agencies have come up with ways to counter the space debris issue.

a. ESA's 'e.DeOrbit mission'

ESA created an idea in 2014 of using techniques to capture or hold the space junk using nets , harpoons , robotic arms and tentacles. This can be an easy method with fewer complications although this would mean that every time a new device will have to be created, if alternative ideas not used. Capture would be conducted in one of two ways: either by using mechanical tentacles or nets. The tentacles option included equipping the spacecraft with robotic arms, one of which will first capture a holding point, before the remaining arms embrace the derelict and secure it with a clamping mechanism. The net option included equipping the spacecraft with a deployable net on a tether, that will envelop the target derelict before the spacecraft will begin changing orbit. The net option has the advantage of being able to capture objects with a wide range of sizes and spins.5

b. Switzerland's 'ClearSpace One'

In 2019, the European Space Agency (ESA) called for experts to submit a solution for removing debris from Space for the first time. ClearSpace was selected, out of a panel of more than 12 candidates, to conduct the first space mission to remove an item from orbit. The mission aims to clean up Space actively while also demonstrating the technologies needed for future commercial debris removal. ClearSpace-1 will launch in 2025. The ClearSpace-1 mission will target the Vespa (Vega Secondary Payload Adapter) upper stage left in an approximately 800 km by 660 km altitude orbit after the second flight of ESA's Vega launcher back in 2013. With a mass of 100 kg, the Vespa is close in size to a small satellite, while its relatively simple shape and sturdy construction make it a suitable first goal,

[4] Satellite collision creates copious space junk | New Scientist

[5] e.Deorbit - Wikipedia

before progressing to larger, more challenging captures by follow-up missions – eventually including multi-object capture.6 It has cubes attached at the side of the planes which safely take the debris out of the orbit. This may be a cheap method but it is not a solution to the problem. They will have to work out a way to reduce the waste and not just take it further away from Earth.

c. Texas A&M university's 'Sling-Sat Space sweeper'

The proposed satellite design, Sling-Sat, also exploits existing momentum to save fuel. Debris is captured at the ends of a spinning satellite. Adjustable arms control the angular rate to achieve a desired tangential ejection speed. Timing the release exacts the ejection angle. Through this process, debris can be redirected to burn up in the atmosphere or, by lowering the perigee; the consequent drag increase will then reduce the debris lifetime. 7

d. Japan's electrodynamic tether

The proposed technology (first announced in 2014) would include a spacecraft that would deploy a 700-meter-long (2,296 feet) electrodynamic tether (EDT) and guide it toward a piece of space junk. The tether would latch onto the orbiting hunk of trash, and the operating spacecraft would then drag the debris down into the incinerator of Earth's atmosphere (causing the operating spacecraft to burn up as well).8 This can be an effective way to reduce the debris but this method cannot be regarded scalable.

e. The British CubeSail

CubeSail will be the first launched three-axis stabilised solar sail, and makes use of a novel center of mass/center of pressure offset technique to provide enhanced attitude control. CubeSail will build on our small satellite experience, such as the STRAND-1 nanosatellite, launched on 25 February 2013. Furthermore, the mission critical sail deployment mechanism has undergone an extensive testing and validation process as part of the ESA Gossamer Deorbiter project carried out here. Several PhD projects are centered on Cubesail's development, and it will serve as a technology platform for at least two further educational satellites developed here. The CubeSail mission objectives are ambitious, and will raise the technology readiness level (TRL) of several technologies to flight demonstration level.9

VII. Factors of reliability

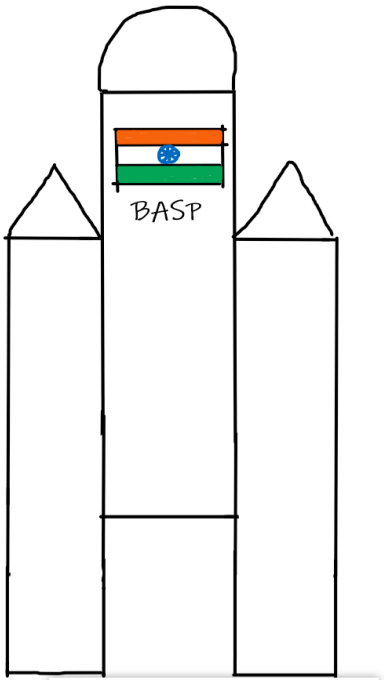
All of these methods seem to be unique and optimistic but still don't live up to the job this mission needs to have. However, most of the missions are still in progress and are continuously developing and upgrading. We need a solution that can be quickly brought into action. The situation is critical and if no action is taken soon, then the problem can become larger. There are four primary factors which decide if a project is suitable or not: costs, scalability, efficient designs and risks. These factors of reliability , developed by me, are the boxes to tick when developing any machine for a space mission. The first and most important point is costs. No space agency can afford to spend millions in every projects. Here , cost also includes time as a cost. Like finances, no agency has many years to brainstorm about a project and then slowly work on it. Everything needs to be in a specific frame of time. An ideal space mission has to be of a minimal cost, to such a point that neither quality is compromise nor the budget. Space agencies have multiple projects in mind at once thus spending too much on one isn't possible; and also shows great inefficiency. The next factor is scalability. A project that only goes out and gets back one piece of debris is completely futile. Thus, the project should be on a bigger scale to gain maximum efficiency. Collecting maximum number of debris should be the primary goal, unlike Japan's electrodynamic tether which cannot be regarded as scalable. A project is a great investment of the scientists' effort and making a device that does not reach a certain benchmark to make a real impact to the problem is a waste of

[6] ESA - ESA commissions world's first space debris removal
[7] Engineering Project Aims To Remove Space Debris - Texas A&M Today (tamu.edu)
[8] Space Junk Solution? Japan Would Use a Tether to Nab Debris & Destroy It | Space
[9] CubeSail mission | University of Surrey

time. Another factor , is efficient design. Every organisation needs to make a machine that can work smoothly. The design should be less complicated so that error finding can be quick and understanding the machine easy. It is obvious that rockets or shuttles cannot have an easy design but making the core and purpose of the machine simpler will automatically reduce complexity and help in facilitating other factors too. The final but a major factor is risk. Sending any rocket in space is a risk in itself. However, every risk should be calculated and all the aspects of it should be considered. The opportunity costs from the risks should be well analysed. Reducing the risk factor is the toughest and should not be brought down to a level where the mission doesn't find out anything new and is not worthwhile. It takes cautious steps to understand the risk involved in the mission, albeit only a risk will lead to progress. Striking a good balance between all the four factors is near impossible. Achieving a good balance between them is what organisations should aim for. There have been only a few projects which have performed well on this scale and are undoubtedly the most successful ones. All the missions above can now be analysed based on these factors and the results will be very clear. We still need a good device that can solve the problem of space debris. Therefore, I have developed my own device to get a break through in this daunting issue raging for years.

VIII. Introduction to my idea

My device shall be known as ' Bhartiya Antriksh Safayee Pranali ' or ' The Indian Space Cleaning System'. This ingenious device BASP will not be a one time use project but will be at the services of ISRO for many years to come. The device can be manned or unmanned and will use re-usable rocket boosters. The rocket boosters will be inspired by SpaceX's latest development and idea of landing the boosters back on earth. This leads to lower costs too. The naming of my creation is inspired by the Indian culture. The main rocket would be known as 'Cheel' or 'Eagle'. The boosters would be called as 'Bheem – 1' and 'Bheem – 2'. BASP is quite a simple yet effective way to clean out the debris from space.

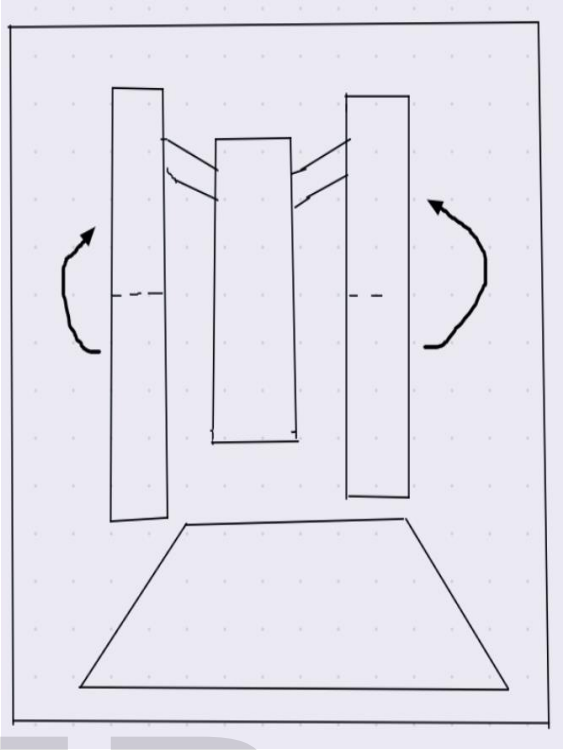


IX. The working

This is the internal part of the main body of the BASP. The specialty of this are the magnets inside. My idea is as follows. After the BASP is in space , the flaps of the body will open , allowing the partially foldable powerful electromagnets to come out. The electromagnets are foldable to save space and increase surface area of the magnet by using a wider and bigger size to attract more of the debris .These magnets will now attract most of the space debris towards it as most of the parts are made up of aluminum or titanium.

The BASP will go towards more crowded orbital regions leading to it being very close to the space debris; thus this reduces chance of high velocity debris colliding with electromagnets as point of magnetic attraction will be very close. These powerful magnets would keep the debris magnetized towards it. There would be sensors attached which will measure the weight of the debris. If a lot of debris is collected then it is possible the electromagnet may break away from the BASP and leading to mission failure. After a certain mass has been reached , the sensors would send signals to the actuators to bring in the magnets along with the debris. The main body of the BASP would act as a storage system. This simply means that the debris won't be thrown further away in space but rather brought back to earth so that it can be treated. Bringing the debris back to Earth also means that the debris can be recycled hence making future missions more environmentally friendly and also reduces the costs. The model can be altered to make even bigger BASP's for more storage allowing more efficient removal of the junk. As mentioned earlier the mission is not a one time use mission, the booster will come very handy in the competition of the mission. After the electromagnets are safely in, the BASP will use the boosters to get thrust to go towards he earths, and then use it to land safely on a designated location on Earth. When refueled and serviced the booster will again serve a mission for us. The boosters can also be used to navigate through space to reach towards the debris.

The reason BASP is highly efficient is that it does not have only one source to collect the debris. Every single existing space debris mission included only one way to collect the debris , but my idea has two separate ways to collect the debris and create a bigger impact. The top most part of my BASP there would be a net made up of fiberglass. Fiber glass ropes are extremely strong and tough. They exhibit high tensile strength. Thus they would be easily holding onto a heavy quantity of debris. Then the net will come out of



the compartment, the space debris would be collected in the net. It can be argued that there is a possibility the net can come in come contact with the boosters and catch fire. It is worthwhile to note fiberglass can withstand temperatures up to 500°C. The net is very far away from the boosters so there is almost no chance of the heat reaching up till the net, and even if it does then the net can withstand up till 500°C so solving the problem as the temperature is unlikely to cross this. Again, using sensors after a particular weight there would be a covering on the net which would ensure that the debris does not leave the net from where it entered. The net is mainly to collect all the non-metallic items which might be in space which the electromagnets cannot attract. The net can be altered to make it impossible for even the smallest debris to escape. The net will stay out from the time it has come out of the compartment. The net will not go back into the compartment but will stay outside itself. The net is quite strong to hold the weight of the debris and force that may oppose it when the boosters push the BASP back to Earth for landing. There is absolutely no doubt that the fiber glass may snap and break. This is a very reliable method to collect more debris and make the mission more useful.

A more environment friendly solution can be that solar panels are attached on top of the BASP to provide energy for the boosters. The massive amount of energy radiated by the sun can be used effectively.

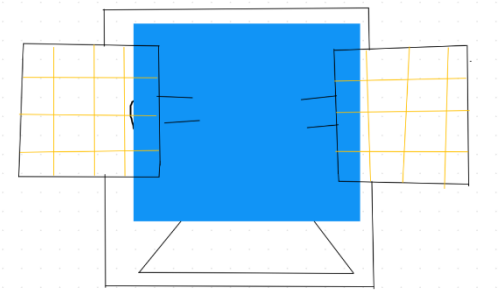
X. Stages of the mission

The whole mission is divided into 4 major stages. The functioning of every stage and smooth transition between every stage is vital for the mission to be a success.

a. Stage 1 – This stage includes the launch of the BASP. The launch would take place from a launch pad in a place a bit far away from human habitation. This to prevent any unanticipated blasts from harming human life. Precision will be a key as any mistake here would mean the end of the mission. I have also come up with an idea to prevent the tremendous amount of smoke released to harm the environment. Therefore, the boosters will be partially submerged in a tunnel which would collect all the smoke released from the boosters and carry them to a different location. Then the smoke can be treated to ensure this is safe to release in the environment.

b. Stage 2 - This is possibly the most important stage of the mission. This stage will decide whether the specialty of the mission which is that it can be re-used will actually work or not. Here the 2 boosters will detach themselves from the main body and land back to the specially allocated different landing pads. The Bheems will detach themselves at a specific altitude to begin the return journey. They will again land very far from human habitation to ensure if any blasts take place no humans are hurt. The boosters after successful landing will be collected , by ships if landing on sea or huge trucks if landing on land and then be taken to be serviced to come back in action.

c. Stage 3 - In this stage, the electromagnets and then net will be released one by one to serve their purpose. Then the magnet will attract all the debris; and while the BASP would be moving the net would capture



the junk. When a particular mass is reached then the sensors would send signals to close the net's opening and the magnets would be called in. The sensors data will be visible back on Earth so we will know how much of the junk has been successfully collected. This will also help to show if there is any fault in the mechanism and the debris is not being collected.

d. Stage 4 - In the final stage, the booster installed in the main body will come out. It would provide the thrust to allow the remaining of the BASP to land back. The booster will aim to create a soft and smooth landing as it will now be of a heavier mass than before and any error can be quite costly. After the landing, the debris can then be removed out and the BASP made ready for another mission. This will mark the end of the mission and will be revolutionary change to fill the void in collecting space debris efficiently.

XI. Why is BASP a better idea than the rest?

The main benefit is that it is highly efficient. The fact that it can be used several times is luring. The amount of space debris that can be collected is very high. If compared with any other method till date, BASP will be the clear leader. This will enable it to create a real impact to the problem. With my device having the ability to be unmanned , it reduces the risk of human loss. If however my device is manned then the control of the BASP will be much more effective leading to better results. BASP also fares well on all the four factors mentioned above. This is a revolutionary method which should be implemented as soon as possible to help mankind

XII. Conclusion

The world has a major issue knocking on its door. Space debris has to be contained now or it can be

an enormous problem. The danger debris possesses is unrealized now. The consequences can be unfathomable. It is the need of the hour to have a good system to contain the space junk. If damages to space missions are happening the same way they are happening now then progress for mankind will be defied by four walls. Mankind is also affected by the debris as the damage can be severe in the near future. It is a collective effort that solves any problem and not just one nation doing the job all by itself. Different countries need to come together to provide resources for the projects to help collectively counter a problem. When all the elite and great scientists come together to brainstorm about the BASP, or any other project the results are bound to come. BASP is a brilliant idea to solve the space junk problem. More developments are essential to accommodate more junk in the main body of the BASP. BASP will be the turning point in space history and will undoubtedly go down as one of the most important projects for the space agencies.

Author name : Aahan Karnavat