CHRISAT-A TECHNOLOGY FOR SPACE DEBRIS MITIGATION

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Abstract— This Study will be a combination of a review paper as well as insight to the author's own model and proposal. The aim of this paper is to support existing technologies which are geared entirely towards space debris mitigation and will serve as a follow up report and opinion on the issue and the recent advancements done to solve the issues. This paper proposes a technique of using 'nitinol nets' to fish out the debris ranging from nuts and bolts that are lost during spacewalks to pieces of older satellites to whole satellites that no longer function. We also plan to bring back the collected debris using Retro Nelumba Technology(RNT) which is cost effective when compared to the existing technology. We strongly feel that this method will be efficient under the mission of **SWACHH ANTARIKSH ABHIYAN (SAA)**. This method shall be explained further as the paper progresses.

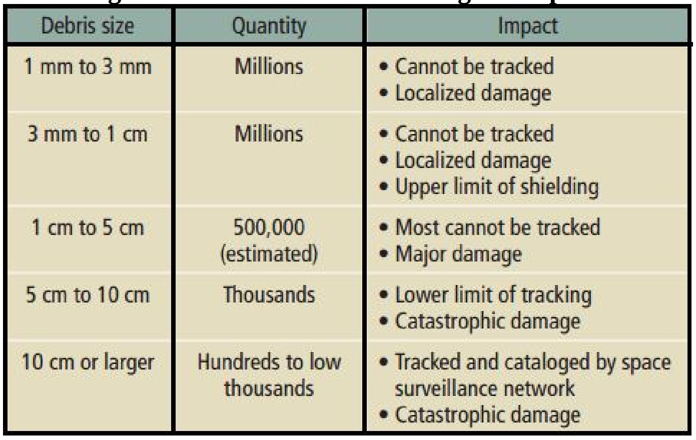
Keywords— space debris, Retro Nelumba technology(RNT),SwachhAntarikshAbhiyan(SAA), Nitinol nets.

I. INTRODUCTION

Space debris is all man- made objects including fragments and elements in earth orbit or re-entering the atmosphere, that are non-functional. It includes fragments generated by satellite and upper stage break-up due to explosions and collisions.

Approximately 6% of them are operational spacecraft, 21% are old spacecraft, 17% are rocket upper stages, 13% are mission-related debris, andremaining 43% are fragments from explosions or collisions. Consequently, about 94% of the catalogued objects no longer serve any useful purpose and are collectively referred to as 'space debris'[a]. The functional satellites represent only a small fraction of the estimated 150,000 or more objects, which are larger than 1 centimeter in diameter, that are currently orbiting in low-Earth orbit (LEO).[b] Most of these objects are fragments of larger objects that have broken up in explosions and other events. Since the velocities of these objects are roughly around 8 kilometers per second (km/s), a collision with any one of these objects is likely to cause a catastrophic damage to a space vehicle or satellite, of which the Space Shuttle and International Space Stations (ISS) are noteworthy examples.

Table1.1: The size and quantity of debris distributed from a given event are factors affecting the impact.



Debris size	Quantity	Impact
1 mm to 3 mm	Millions	• Cannot be tracked • Localized damage
3 mm to 1 cm	Millions	• Cannot be tracked • Localized damage • Upper limit of shielding
1 cm to 5 cm	500,000 (estimated)	• Most cannot be tracked • Major damage
5 cm to 10 cm	Thousands	• Lower limit of tracking • Catastrophic damage
10 cm or larger	Hundreds to low thousands	• Tracked and cataloged by space surveillance network • Catastrophic damage

Since the operational lifetimes are generally much shorter than when compared to the orbital lifetime of LEO and that of GEO satellites, it becomes clear that some active mitigation of debris creation in these regions of space is required. In the case of LEO, both inadvertent and a few deliberate destructions have added significantly to the debris population. New developments such as constellations of communication satellites may increase the population further. To minimize the collisions among objects large enough to generate substantial further debris, measures have to be taken in order limit the orbital lifetime of non-functional satellites will be required. While the concern of space debris is a recent phenomenon, the accumulation of discarded objects started at the dawn of the space age on that fateful

October day in 1957, when the USSR decided to launch Sputnik 1. No one had an inkling that the exploitation of space would eventually lead to the trashing of earth orbits[c]. In 1983, a tiny titanium oxide paint chip, estimated to have been about 0.2 millimeter in diameter, collided with the shuttle orbiter CHALLENGER, at very high velocity, damaged a window. Although the damage posed no immediate danger, the window was weakened beyond the allowable safety limits for re-flight and was replaced before the orbiter’s next launch. Moreover, NASA and other space agencies predict that despite the mitigation and control steps undertaken the space debris will increase gradually over the next 200 years which will be a potential disaster to many new upcoming space endeavors planned or yet to be planned.

The Kessler syndrome which is the main cause of increase in the population space debris and poses a great threat for the survival of satellites.

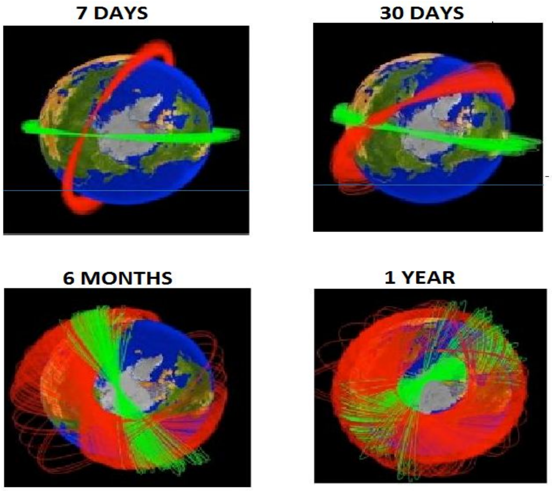
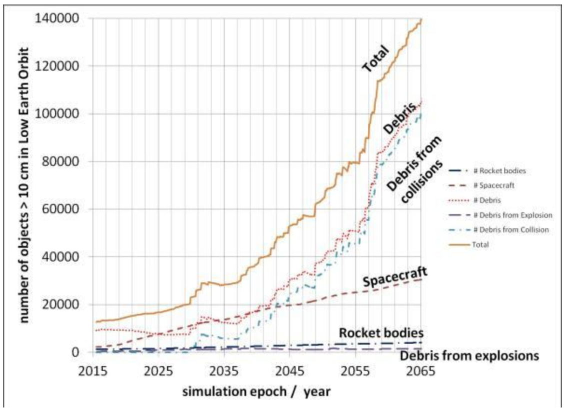


Fig 1.1(a) shows the Spread of debris orbital planes.

It has been estimated that if the ISS will be destroyed in an event, it would result in a mega cascade of several thousand debris particles which would make it highly impossible for any space faring nation or agency to launch a satellite for the next 50 years.



Graph 1.1(b) Number of space debris in LEO over time for a single simulation run using the deployment scenario.

II. THE FGAN SYSTEM

The main subsystems in the FGAN Tracking and Imaging Radar (TIRA) are: a 34-m parabolic antenna, a narrow-band mono-pulse L-band tracking radar, with a high-resolution Ku-band imaging radar. The sophisticated, fully computer-controlled, 34-m parabolic Cassegrainian-feed antenna is mounted on an elevation-over-azimuth pedestal. It is shielded from atmospheric disturbances by a rigid 49 m-diameter radome.

The main space applications of TIRA are:

– searching for and tracking space objects (orbit determination)
– characterization of the space-debris environment
– tracking re-entering (risk) objects
– imaging space objects (verification of operational procedures, attitude determination, emergency operations, damage and fragmentation analysis)
– radar measurements of meteoroid streams.[1]

Along with TIRA there are many technologies which play an important part in tracking the space debris.

III. TECHNOLOGY FOR SPACE DEBRIS MITIGATION - CHRISAT

We propose the method of using nets for clearing the space debris which are between 1 cm– 20 cm in size. The motion of the satellite will be in the direction of the space debris. Once the satellite reaches the same relative velocity as that of space debris, the satellite gets gentle nudge with the help of propellers, thus increases the velocity of the satellite by a small fraction. The satellite then reaches the debris, and catches it.

IV. SUB SYSTEMS

- **Communication System:**

Comprises of two wayradio communications arrays enabling live broadcast of satellite telemetry from all systems and providing ground control with an interface for controlling satellite systems.

- **Electrical Power System:**

The electrical power system is made up of a dual axis gimbals actuated solar panel array which provides power to a battery bank through a power converter.

- **Orbital Intercept and Thrust Control System (OITCS):**

This system records space craft velocity, altitude and orbital information and performs orbital maneuvers to intercept targeted debris. These intercept operations are performed following a pre-programmed course determined to be the most efficient path between targeted debris.

- **Attitude Determination and Control System (ADCS):**

This system records and controls the satellite’s rate of rotation and orientation and is responsible for stabilizing disturbance torques.

- **Thermal control systems:**

We use both active and passive thermal control systems for the satellite. This will change its performance when it is at its initial stage by the pre-programmed controller.

- **The Nitinol net:**

This is the main part of the satellite. This is compressed in a efficient way before it is launched, and due to its shape memory property, it will regain its shape in its due course.

V. METHODOLOGY

The net which is completely crushed is made of nitinol, an alloy of nickel and titanium. This alloy has a unique property called a shape memory. This alloy will be given its shape in the austenite phase. The shape given will be a frustum.
At the perihelion, the PTCS is constructed for both the main satellite and the nitinol mesh. When the satellite is at its first exposure, PTCS and ATCS apply only to the mother satellite and the 4 cubesats. The ATCS makes sure that it sends only the required amount of heat to the mesh so that it will regain its original shape. This should take around 10 to 30 seconds. The time taken for the complete satellite to expand and presume its programmed shape solely depends on the complexity with which the nitinol is crushed before launching. In our case we have the complexity order of 1.
As soon as the satellite gets it programmed shape, then it starts to collect the debris. Once a debris enters the satellite, then a shutter which is placed on one of the side of the satellite closes. This happens till the whole satellite is filled with debris. Once the whole satellite is filled with it, the shutter closes, the dome containing the reentry technology closes over the satellite and then starts its descent. We aim to bring back the space debris back to earth, as the ‘junk’ that we refer to, also contains meteorites, and many other technologically valuable ‘junks’ that are worth bringing back.
Our satellite aims for debris which are between 1-20 cm.. The ‘mother satellite’ will get to know about the existing debri’s trajectories through OBC(onboard computer system) whose diameter is above 20 cm from technologies like TIRA. If the sensors senses any of these trajectories to be intersecting with that of its own, then it sends command to the cube sats after calculating all the necessary parameters, which in turn will steer the satellite to a safer orbit if necessary.

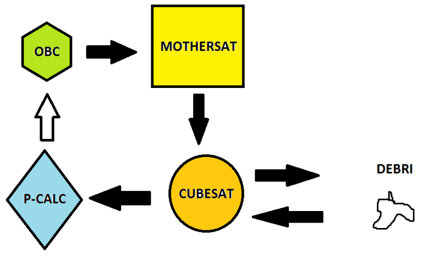


Fig 1.2 shows the block diagram of passage of information signal in the satellite system.

IV. ADVANTAGES

This method will be cost effective, and can revolutionize the space conquest.
The most crucial aspect of this method is that while current techniques are limited to the de-orbiting of only one inactive satellite in one mission, but this method has the potential to de-orbit hundreds of defunct satellites at a single time.
Satellite can be made reusable, for instance refueling the satellites, dumping the present debris back to earth and continuing its mission. This gives us the efficient way of clearing the space debris from space and making the space less hostile for the satellites.

CONCLUSION

- The future of space flight is at risk due to the Kessler Syndrome, space remediation is necessary to secure that future.
- CHRISAT would be an efficient and a reliable technology to rely on for a clean space environment.
- The only plausible way clearing out the space junk permanently is to make sure that whatever satellite that humans send up to the atmosphere, is bought down back to earth or is thrown out of earth’s orbit. If not it will be an endless loop, where one cleans up, and the other puts the dirt back again.
- The present catalogue does not contain the debris which are of the size less than 10 cm due to the difficulty in tracking them. The proposed technology will give a new way for cataloging these space debris.

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