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GPS based Debris Removal System

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Abstract: The various kind of space debris that are revolving around over the earth in an orbit passed threat to satellite communication. Artificial debris installed with GPS (Global Positioning System) can be set to orbit in a region where the debris population is high. The movement of the debris can be detected using GPS. and by using a laser broom, which is nothing but a highly intense laser beam with a power of several orders of mega watts, the various size of debris present in that region can be deorbit.

Keywords: catastrophic debris collision, Electrodynamics Tethering, Laser Broom, momentum Exchanging, Radiation

I. INTRODUCTION

As Newton said, “For every action there is an equal and opposite reaction”, the development in the satellite technology heads in one direction launching many satellites and the debris created due to these satellites possess a threat of destroying the satellites and heads in the opposite direction. In the next 100 years, man’s thirst for wider and better universal communication will lead in launching of many satellites which in turn produces huge amount of debris. The space around the earth would get so congested that it needs to be cleaned.

Satellite collisions due to debris are increasing at an alarming rate. Since the solar panels are delicate .Even very small size debris could be a cause for the malfunctioning of the panel, which in turn reducing the efficiency of data transfer Thousands of nuts, bolts, gloves and other debris from space missions form an orbiting garbage dump around the Earth, presenting a hazard to spacecrafts. Some pieces scream along at 17,500 mph. Junk, which are created by rocket explosions, can rip holes and disable a satellite by causing electrical shorts that result from clouds of superheated gas, that are sometimes generated in an impact. Satellite collisions due to debris are increasing at an alarming rate. Since the solar panels are delicate .Even very small size debris could be a cause for the malfunctioning of the panel, which in turn reducing the efficiency of data transfer.

II. OBSERVATION AND TRACKING

Space object tracking is the process of predicting future locations of space Objects and subsequently prescribing avoidance maneuvers to sidestep Potential collisions. Tracking differs from simple observation and requires more complicated calculations and a network of strategically placed sensors around the globe. In the past years, significant debris-generating events as well as improved tracking abilities have encouraged the recognition of space debris as a significant threat. The impact of space debris on space security is related to a number of key issues, including the amount of space debris in various orbits, space surveillance capabilities that track space debris to enable collision avoidance, as well as policy and technical efforts to reduce new debris and to potentially remove the existing space debris in the future. The space around the earth would get so congested that it needs to be cleaned. This problem is neglected by peoples because it looks insignificant but it is of great concern for the developments in space and technology. This paper outlines the problem of space debris and gives solution on it with help of GPS based space debris removal system

III. PROPOSED SYSTEM

There are quite a lot of prototypes to avoid the space junk problems. As an engineer’s we have the responsibility to keep our environment clean, which extends up to space.

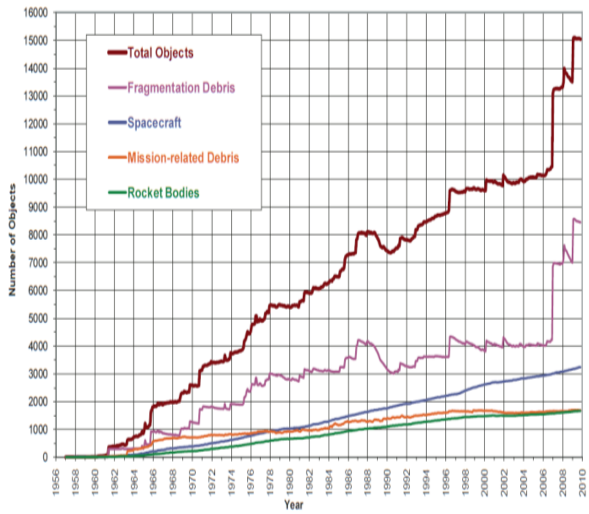

Figure1: Growth of the space debris field (catastrophic debris collision)

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A) Possible Steps to Remove Space Junk

Some proposed techniques to reduce or eliminate the manmade debris are as follows:

- Attaching rocket motors to debris.
- Satellites maneuvering and shielding techniques.
- Electrodynamics tether.

Some ideas proposed to remove the debris using radiation pressure by the following methods.

- Debris deceleration using the radiation pressure of laser beams.
- Focusing of sunlight (lensing) on the debris and decelerating it.

1 Attaching Rocket Motors To The Debris

This technology can be applied to remove orbital debris from low earth orbit (LEO) . Rocket motors are attached to debris like the dead satellites, spent rocket stages, larger fragments of the satellite breakups can be decelerated. A rocket motor is attached to the debris using a space shuttle mission from the earth.The motor is triggered at a direction opposite to the movement of the debris. Thus the junk velocity and its altitude decrease. The debris is bringing down to the atmosphere. Where it is burned up due to friction with the atmosphere. As this method needs a separate space mission to send the required components to perform the operation, it is cost very high. Rocket motors can be stored in the International Space Station and can be used to bring dead satellites down. This is a cheaper and efficient method.

2 Satellite Maneuvering and Shielding

The modern satellites and space probes that are to be launched in the future must have various type of maneuvering options so that it escapes from being hit by a junk that is unable to be detected by the ground based radars. It have to be designed in a way that it can withstand hypervelocity impacts of debris. The whole satellite is not maneuvering because the communication signals might get interrupted. In order to protect the functional part from the impact of the small debris these parts are shielding and the delicate parts like solar panels are manoeuvring.

3 Electrodynamics Tether

Electrodynamics (EDTs) operates on principle as generators by converting their kinetic energy to electrical energy. Tether One of the latest developments in the space junk removal program is that of the introduction of the electrodynamics tether. This is a conducting wire i.e., several tens of kilometers in length and is controlled by a spacecraft. Tether is essentially something which is used to tie one object to another. On Earth, a tether is something which is generally used to keep something in place. In space, it has many useful purposes.

According to faraday's law when a current carrying conductor cuts a magnetic field, forces will develop in the conductor, which is in a direction opposite to the cause of its movement. As the electrodynamic tether passes through earth's magnetic field, A voltage is setup along the tether. And this voltage makes electrons to flow down the tether, similar to water flowing down a pipe. If the tether has a right to collect and emit these electrons, then an electrical current (the flow of electrons) will move through the tether. Whenever an electrical current flows in a magnetic field, a force will develop and this force is used to manoeuver the tether. Solar panels are using for energy requirement of tether.

A small vehicle called the space sheepdog will accompany the tether. This vehicle will be released to the near place of debris, it will fly around and latch to a suitable point. Once the debris is attached to the space sheepdog it brings it to the tether and gets connected with it. At that moment the current in the tether is made to flow in a direction such that the tether is brought down into sub orbital levels along with the debris. Thus the debris is deorbited. The tether is once again raised to higher altitudes by changing its current direction. This is how tether is reusing many times to clear the debris.

B) Deceleration of Debris Using Radiation Pressure Radiation Pressure

The pressure exerted by light on an object is called radiation pressure. By using the radiation pressure we can generate a force in a direction opposite to that of the debris thereby slowing it down. Radiation pressure is equal to Force exerted on debris/area of debris.

By Einstein"s equation,

E = mc2 (3.1) Momentum, p = mc (3.2) Therefore,

E = cp (3.3) W.K.T, From eqn(3.3),

Radiation pressure (R.P) = Rate of change of momentum per unit area

p = E/c

dp/dt = dE/dt*1/c

W.K.T, power = rate of change of Energy = dE/dt

Therefore, dp/dt = power/c

R.P = power/(area ∗ c)

W.K.T. Intensity (I) = power/area

Radiation pressure (R.P) =intensity of light/velocity of light Radiation Pressure = I/c (3.4)

(For total Absorption)

R.P= 2I/c (for total reflection of light).

For an object to remain in orbit at altitudes below 620 miles (1,000 km), it have to travel at a speed of around 18,000 miles per hour. Within this region of space critical satellites and craft, including International Space Station and the shuttle are operating. In order to deorbit the debris its velocity should be reduced below 18000 mph. The intensity of radiation required to deorbit the debris can be derived as follows:

By the law of conservation of momentum, If two objects collide,

The momentum lost by one object = momentum gained by the other.

Momentum loss of incident radiation= Momentum gain of debris

But, radiation pressure=rate of change of momentum/Area (from(3.4))

I/c = dp/dt ∗ 1/c (For total Absorption) = m ∗ dv/dt ∗ 1/A where dv = v1 − v2 v1=velocity of debris v2=velocity at which debris deorbits (i.e. less than 18000 mph)

Therefore intensity of radiation required will be,

I = mc/A ∗ (v1 − v2)/dt (3.5)

dt = time required to reduce the velocity from v1 to v2

As all the quantities are constant,

Intensity of radiation inversely proportional to the time required**.** So if the intensity of radiation is more large, then the time taken to deorbit the debris will be small.

C) Deceleration of Debris Using Laser Beam

The word LASER stands for Light Amplification by Stimulated Emission of radiation. The laser beam is monochromatic, coherent, and highly intense and it will not diverge. By using a highly intense laser beam we can slow down the debris thereby allowing it to reenter earth's atmosphere. The required intensity of the laser beam is directly proportional to the mass and inversely proportional

to the surface area of the debris. It is difficult to deorbit the debris that is smaller in size since radars and other detecting devices cannot spot the debris that is smaller in size An example to show the possibility of using laser beam to de orbit the debris is as follows,

Consider debris of mass 10g present in an area A, orbiting with a velocity of 10 Km/s. To de orbit the debris it should orbit with a velocity less than 8Km/s.

Eqn (3.5) gives,

I = mc/A ∗ (v1 − v2)/dt

Also W.K.T. I=power/A→power=I*A

Therefore Power = mc(v1-v2)/dt

Time required to de orbit debris = dt

dt = mc(v1 − v2)/power of laser beam

Consider the use of laser beam with a power of 20MW.

Therefore,

Time = 0.01*3*10^8*(10000-7800)/(20 *10^6)

(Since velocity of debris should be less than 8000m/s, we taking the velocity the as 7800m/s.) Amount of time for which the laser beam should be focused on the debris is equal to 330s.

This is possible if we can do it from the ISS it would not cost much either. Artificial debris installed with GPS (Global Positioning System) can be set to orbit in a region where the debris population is high. We can detect the movement of the debris using GPS. And by using a laser broom, which is nothing but a highly intense laser beam with a power of several order of mega watts, The various size of debris present in that region can be de orbit.

After laser brooms sweep the debris, it will slow down and come to sub-orbital levels at last reentering to the earth‟s atmosphere thus getting destroyed or burned due to friction. As the artificial debris is also among those being swept it would be possible to observe the path taken by the debris during their reentry phase, which is very useful for future analysis.

V. ADVANTAGES

The main benefits are follows: It can track and target debris with a much larger field of view also it focuses on the targets for a longer periods of time. Providing efficient satellite Communication. it is a feasible way to remove 1 to 10 cm debris from LEO. Unlike other debris removal methods it will not provide any negative atmospheric effects. It can act as a space based weapon system.

VI. LIMITATION

*In LASER technology, LASER should have high illumination power and high cost.

*GBL(Gound base laser) cannot be moved freely in a huge range.

VII. CONCLUSION

Debris poses a growing threat to satellites, which provide critical services such as communications, navigation and Earth monitoring. By instituting global space debris removal measures, a critical opportunity exists to mitigate and minimize the potential damage of space debris and ensure the sustainable development of the near-Earth space environment. As "prevention is better than cure". The efficiency and time period of satellite can increase by the use of debris removal system, i.e. the destruction can be prevented of the satellites. "The beginning is always today" should be the approach; otherwise the future will be a in dark.

VIII. FUTURE ENHANCEMENT

An elegant, cost effective, and feasible approach is to use laser technology the development of this technology will stimulate other approaches, including laser power beaming, deflecting asteroids, meteoroids, and comets, and propulsion for interstellar missions.

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