By Peter Greenstreet

**Satellites What Harm Can They Do?**

What effect can manmade satellites in our atmosphere have on our earth? Firstly, manmade satellites are defined as “an artificial body placed in orbit round the earth or another planet in order to collect information or for communication.”¹ Manmade satellites have been sent into the atmosphere since the end of the 1950's, with the first being sent up by the Soviet Union called “Sputnik 1”² (sent into space on 4th October 1957). Now the Goddard Space Flight Centre lists 2,271 satellites orbiting earth: so how much effect is this having on our environment?

One question is “what effect does space debris have when it comes crashing to earth as a result of satellites colliding - either with other man made satellites or with natural satellites or exploding due to technical issues?” The satellite debris is called “space junk”.³ Space junk travels around the earth at about 7.5 kilometres/second. This means that even tiny pieces of space junk can cause huge damage to other objects in the Earth’s ionosphere (the layer in the earth’s atmosphere which satellites are in.) When space junk is fired into the earth’s atmosphere it is broken down by the heat caused by the friction between the air and the debris (this can reach temperatures of up to 3000K/2727°C). It is this process of satellites breaking down which causes shooting stars which can be either manmade or natural satellites such as rocks. So what damage has this done? Negligible: as most of the time they never reach earth with any dangerous mass and any small pieces only have a 1 in 3,200 chance of hurting anybody⁴ as it is broken down into tiny particles as it burns up.

Another question is “Do rocket astronauts have to consider satellites as they leave Earth to travel into space?” Yes - for the simple reason that satellites travel so fast that the force of even a small piece of metal in space will cause huge damage to rockets. Rockets make it into space because the Department of Defence (in the USA) maintains a highly accurate satellite catalogue of objects in Earth’s orbit that are larger than a softball.⁵ By using very clever computer programs which adjust the ship’s course as it goes up into space, scientists can make sure a rocket avoids all these space objects. This is becoming harder and harder because there is more debris, however there are now new space missions to clean up our ionosphere by NASA and many other countries’ space teams. They have still not found the most effective method but they are considering different methods:

1. Snagging and Moving Space Junk: The e.DeOrbit mission will seek out satellite debris in a polar orbit at an altitude between 800 and 1,000 kilometers. The European Space Agency is considering several kinds of "capture mechanisms" to pick up the debris, such as nets, harpoons, robotic arms and tentacles.

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¹ [https://www.google.co.uk/search?sourceid=ie7&rls=com.microsoft:en-US&ie=utf8&oe=utf8&q=definition%20of%20satellite&safe=active](https://www.google.co.uk/search?sourceid=ie7&rls=com.microsoft:en-US&ie=utf8&oe=utf8&q=definition%20of%20satellite&safe=active)
2. Pushing Debris Out of Space: CleanSpace One, a technology demonstration spacecraft, is expected to launch in 2018 from the back of a modified Airbus A300 jumbo jet. The Swiss Space Systems satellite would then meet up with a decommissioned SwissCube nanosatellite to move it out of orbit.

3. Using the Power of Electricity: The Japanese Aerospace Exploration Agency proposes to use an electrodynamic tether whose current would slow down the speed of satellites or space debris. This would make it gradually fall closer to Earth, where it will burn up.

4. Solar Sail: A British proposal called CubeSail would use the drag of a solar sail to push orbiting space debris down to lower orbits.

At the current moment all these suggestions offer hope for the future but are nowhere near ready for use. So for now there are still huge issues in the quest to clean space as well as it being such an expensive process.

“How many resources does it take to build, send and run Satellites?” This question is becoming more important with climate change which is caused by the burning of finite fuels, e.g. the fuel burned in large quantities during take-off. It is the release of CO$_2$ from burning these fuels which is thought to be causing the increase in world’s average temperature. As you can see in figure 6 as the CO$_2$ increases there is a direct correlation with the increase in temperature. This is because CO$_2$ is a greenhouse gas, meaning it absorbs the infra-red radiation from the earth. The photon of energy the CO$_2$ absorbs is then released in all directions, sending some of the infra-red back to earth. Without any greenhouse gases the earth would be uninhabitable as temperatures would drop to that of temperatures similar to Mars at night as all the sun’s energy would escape. This would mean temperatures of about -153°C. However plants and animals working together keep the earth at a constant correct level of CO$_2$ to O$_2$ ratio. The extra CO$_2$ being added to the earth by human interference results in the world’s CO$_2$ concentration becoming too high. This has led to the warming of the troposphere (the layer of the atmosphere closest to earth where the greenhouse gases are). This creates many problems, and not just that the air gets too hot, including increase in storms, flooding and the icecap melting resulting in higher sea levels.

As well as fuel used to power the rockets there is also environmental damage caused by the mining of materials used in the construction of satellites. Sulfide-containing minerals are released into water during mining, which oxidizes with the air to form sulfuric acid. This, when combined with

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6 http://www.space.com/24895-space-junk-wild-clean-up-concepts.html
7 http://www.google.co.uk/search?q=temperature+of+mars&safe=active&rls=com.microsoft:en-US&q=temperature+of+mars&spell=1&sa=X&ei=NonHU_n9DOSx0QWeu4CYDQ&ved=0CBwQvwUoAA&biw=1366&bih=652
trace elements, negatively impacts on ground water. This happens from both surface and underground mines. Leftover chemical deposits from explosives are usually toxic, and increase the salinity of mine water. In the extraction of some minerals, some toxins spill into water supplies ending up in the oceans and lakes. Also, Acid Mine Drainage lowers the pH of the water, making it more acidic which can kill marine life resulting in the destruction of many ecosystems.\(^8\)

All types of mining have huge effects on the quality of the air. Since mines need to blast through rock to get to an ore, dust is produced in the process. Coal mines release methane, which contributes to environmental issues because it is a greenhouse gas. When radioactive elements are found in the ore, radiation is emitted. Heavy metals, such as sulfur dioxide, may escape into the air causing acid rain and smog. As a result of mining, 142 million tons of sulfur dioxide is emitted into the atmosphere each year. That’s 13% of total global emissions.

There are many different ways of mining metals, such as open pit mining, deep-sea mining and coal mining; Which all coming with their own environmental issues. Artisanal Mining is used to extract Rare earth elements and other high demand metals in aeronautical engineering. Rare earth elements are rare substances which play a key role in the production of satellites. There are 17 rare earth elements (REEs); they are yttrium, scandium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.\(^9\) An issue of artisanal mining is toxic substances such as mercury and cyanide are used to extract gold and other rare elements from the land. The mercury used can get into the bloodstream of smaller animals resulting in the pollution of the whole food chain. If the mercury used were to accidentally spill, the damage done would be irreversible. This technique is often accompanied by widespread environmental degradation, both during operations and long after mining activities have ended. For each 500 to 800 tons of gold produced, 800-1000 tons of mercury are emitted!\(^10\)

These issues add fire to the important debate as to whether it is worth sending satellites into space and causing all this environmental damage. However one main advantage with manmade satellites is that once they’re in space they cause no further damage as a result of combustion of fossil fuels. There are two main reasons: First; almost all satellites are solar powered\(^11\) (this is because there is no way that you could store enough fuel on a satellite to power it for the decades it is needed in space.) The other reason they are solar powered is because throughout the day they have a constant level of light from the sun due to the fact that there are no clouds in space. The second reason that you don’t need to worry about fossil fuels is that any fuel fumes released by the satellite during the start of configuration will be broken down by the highly ionising U.V radiation from the sun. So once the satellite is in space it is no longer an environmental problem. It is the manufacture and getting of the satellite into orbit that causes the problems.

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\(^8\) [http://www.safewater.org/PDFs/resourcesknowthefacts/Mining+and+Water+Pollution.pdf](http://www.safewater.org/PDFs/resourcesknowthefacts/Mining+and+Water+Pollution.pdf)


When looking at satellites we also need to consider if they do any good for the earth’s environment:

1. We use satellites to study issues with the ozone layer: it was the use of NASA satellites which verified the hole in the ozone layer. It was this proof which convinced most countries to ban the use of CFCs\(^\text{12}\) (highly unreactive chemicals which get into the stratosphere and break down \(\text{O}_3\)). This was causing the hole in the ozone layer allowing the more damaging U.V C and B (the most ionising U.V radiation) to get through where it damages living organisms causing diseases like cancer.

2. We use them to check countries are not producing more carbon dioxide than they are allowed by the U.N. This is important in relation to control of greenhouse gases.

3. Another positive effect of satellites is the way that they can be used to trace weather patterns which means that countries know when weather systems such as tidal waves and hurricanes will hit so they can try to protect people and the environment in the time before such things reach land. It also means that weather forecasting can now be much more accurate.

4. Furthermore satellites are used to track temperatures and pressures across the world meaning we can build a better picture of the environment, allowing scientists to make more accurate predictions when developing different projects. E.g. when they design tidal barriers to create electricity they can run accurate simulations as they know all the possible conditions it will face in set places on Earth.

As well as all these environmental benefits Satellites have many essential roles in modern human life from Satnav systems, to global telecommunications and many military uses.

To conclude then, satellites do harm the environment. This is because of the release of fossil fuels and the damage caused in the extraction of metals as well as the issues with space debris around the planet. However the harm to the environment by the building of and the use of satellites is negligible compared to all the other projects that harm the environment so much more. E.g. the use of cars makes more fossil fuel damage and personal electronic goods require greater rare earth element mining. The problem of space junk is a big one; however the only thing it really affects is other satellites and rockets so therefore I believe the positive uses of satellites far outnumber the problems with them. To answer my initial question it cannot be denied that the use of satellites has huge effects on the Earth’s environment and our way of life but the positive uses outweigh the negative environmental issues.

\(^\text{12}\) \url{http://www.epa.gov/ozone/science/sc_fact.html}