

'Are Satellites Sustainable?' - by Mia L

The first artificial satellite in space was the Soviet Union's Sputnik 1 in 1957. This initial Sputnik lasted just 3 months in orbit before crashing back down to Earth, but since then there have been huge strides in satellite technology. Today, there are over 1,100 man-made satellites orbiting the Earth, each with specific responsibilities: weather forecasting, communications and GPS to name a few. Whilst their usefulness is inarguable, the subject of their sustainability is questionable.

Most satellites are put into orbit by rockets, which require vast amounts of fuel to leave Earth. A study from University College London, the University of Cambridge and Massachusetts Institute of Technology (MIT) found that the particles emitted by rockets are nearly 500 times more effective at holding heat in the atmosphere than all other sources of soot combined, enhancing climate change hugely. Furthermore, they also discovered that rockets using Rocket Propellant-1 (RP-1, a highly refined kerosene fuel that is one of the most popular fuels for rockets) expel 1 gigagram (1000 metric tons) of black carbon (soot) into the stratosphere, and this could reach 10 gigagrams a year in the next few decades if the rate of increased rocket launches continues. Soot is not the only greenhouse gas emitted by rocket launches, Elon Musk's SpaceX Starship SN15 released 358 tonnes of CO₂ (for context, the average UK citizen has a carbon footprint of 12.7 tonnes) and it has recently been discovered that aluminium oxide is another bi-product of the launches. These particles absorb outgoing long-wave radiation so also contribute to global warming. Moreover, with the growing space industry, this will worsen quickly.

Once satellites are in space however, they can be used for good. For example, through weather, temperature and air pressure predictions we could improve farming efficiency for specific areas, optimising agricultural yield, so producing less waste and increasing sustainability. Weather forecasting can also enhance renewable energy infrastructure, for example looking at sunlight and cloud cover could reveal optimal locations for solar panel installation. Satellites can also be used to monitor the atmosphere's concentration of greenhouse gases such as aerosols, water vapour, carbon dioxide, carbon monoxide and methane, as well as the effects of their increase: rising temperatures, flooding, changing weather patterns, increased natural disasters, wildfires and coral reef bleaching for instance. With this data, we can review the areas most needing improvement and aid in order to make a more sustainable future.

Today there is a growing threat of space debris: millions of pieces of space junk flying around low Earth orbit (LEO). The debris consists of things such as abandoned parts of rockets, satellites out of commission, and even flecks of paint – all of which are byproducts of satellites. In LEO, the debris can reach incredible speeds, posing a huge threat to other satellites and spacecraft no matter the rubble's size. One of the estimated 130 million fragments less than a millimetre in length actually hit and damaged the International Space Station in 2021, and its astronauts are constantly prepared to board an escape capsule should the destruction be threatening. Furthermore, when space hardware re-enters the atmosphere, at least half of the debris ends up as re-entry smoke particles (RSPs) which have unknown impacts.

Another use of satellites is natural disaster detection. Take Japan's Himawari 9 for instance, which, with the help of its predecessor, takes a full picture of East Asia and the Western Pacific every 10 minutes to maximise warning time before disaster strikes, allowing more lives to be saved. A United Nation study discovered that 52% of the world's population is without internet access, with 90% of them from developing countries. More satellites could allow a further three to four billion people access to the internet, which would in turn aid in education, technological advancements and awareness around the world, all important factors in long term sustainability.

Overall, I believe that currently, our use of satellites is not sustainable. Although there are continued technological advancements, for example eco-fuels and increased lifespan, that will lessen satellites' impact on the environment, our abuse of them will have terrible long-term effects. SpaceX aims to launch 42,000 satellites to create a mega constellation, which will undoubtedly increase greenhouse

gas emissions, space debris and overall pollution. However, I think that if we make changes and invest more in sustainable space initiatives such as Active Debris Removal, we can continue to benefit from satellites' incredible applications while preserving our Earth for the future.

Mia L