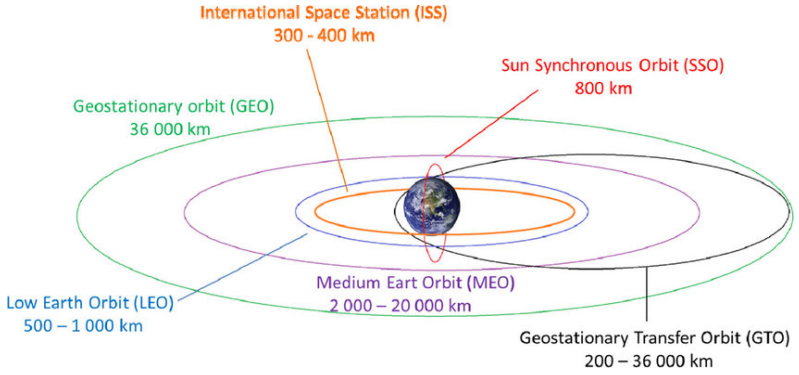
Project

2018/2019 *FIRST*® LEGO® League INTO ORBIT℠

Problem

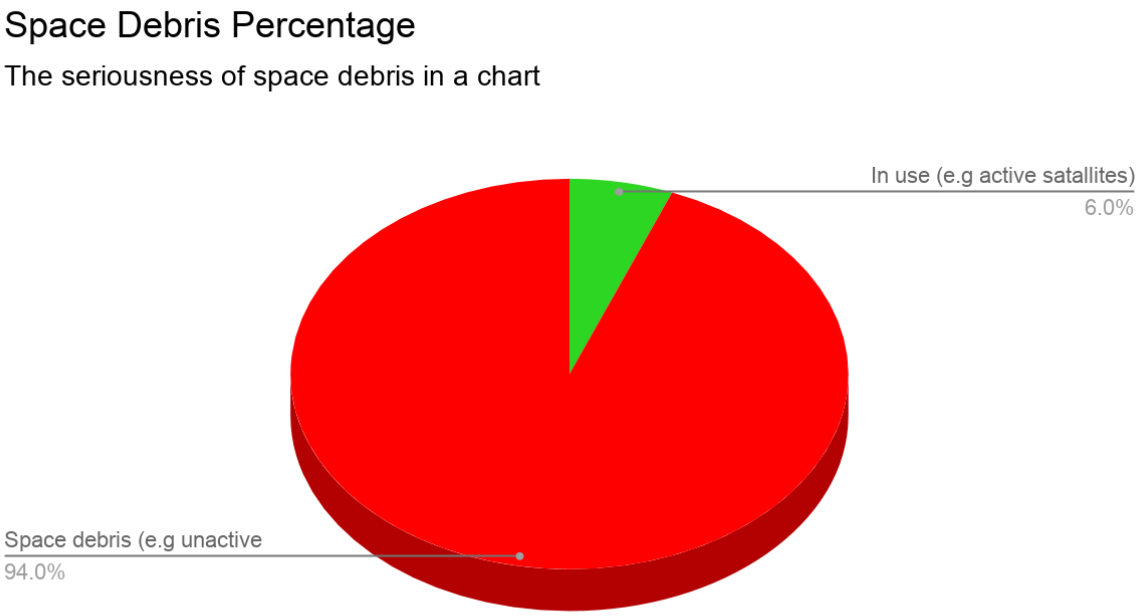
Our planet Earth's orbits are full of space debris. All ready, this year there are 500.000 trackable pieces of space debris. Space debris are considered all objects on orbit with no purpose such as old rockets (rocket bodies), destroyed or disintegrated fragments/shrapnel from objects collisions and old useless satellites. We talked with experts and they confirmed that space debris is an actual problem (for example Rauno Gordon, Laurits Leedjärv and Mari Allik), in total there are around 170 million pieces that could damage the International Space Station (ISS). Earth has five orbits, where satellites are sent and that's why space debris is also present there.
500-1000 km away from Earth is the Low Earth Orbit (LEO), where 273 satellites are.
600-800 km away from Earth is the Sun Synchronous Orbit (SSO), where 197 satellites are.
2000-20000 km away from Earth is the Medium Earth Orbit (MEO), where 69 satellites are.
200-36000 km away from Earth is the Geostationary Transfer Orbit (GTO), where 36 satellites are.
36000 km away from Earth is the Geostationary Orbit (GEO), where 424 satellites are.



Satellites we currently use make up only 6% from all the objects on orbit, other 94% is space debris. For example a Egyptian satellite was active on orbit for only **3 weeks**. In a few years it'll be space debris and will danger people on orbit.
The addition of satellite programs and the collision of old satellites will only add to it. Here you can see the satellites in operation and space debris from 2 cm in size. If space debris (grey dots) don't appear, click 'Display rocket bodies and debris'.
This graph is made by The University of Texas at Austin.

The seriousness of space debris

Space scientists know the space debris danger as the Kessler syndrome. Namely, National Aeronautics and Space Administration (NASA) scientist Donald J. Kessler in 1978 introduced a scenario, where our Low Earth Orbit would have so many satellites, that with every collision the next occurence will follow: fragments will destroy even more satellites and will be dangerous to our next space missions they also might collide with the ISS.
In the event of such a scenario taking place, the launching of the satellites will become virtually impossible after some time and thus the space technology race will also be interrupted. Also the chance to send people to the Moon or Mars would also cease, which means we would be prisoners on our own planet.



Luckily most of the satellites on the Low Earth Orbit slowly disappear because of airborne air resistance and it manages to hold our orbit a bit clean.
However, the effectiveness of this impact depends on how many satellites are added each year. Orbital floating space debris can reach up to 56,000 kilometers per hour thanks to the Earth's rotation. At such speeds, even a centimeter piece of space scrap can cause serious damage to satellites and space stations. However, larger pieces of this can already lead to catastrophic shattering and intensify the progress of the Kessler scenario. If the thing went so far, a near-earth orbit would sink into space debris. With the current pace of satellites being added, a layer of broken satellites and fragments will circulate the orbit by 2209, so that any exploration of space will become largely impossible on both manned and unmanned journeys. According to the International Space University (ISU) 2012 estimate, the damage

from space debris alone was about 20.000.000 United States Dollar (USD) that year alone, and it will be about 35.000.000 USD by 2055 (equivalent in 2012). These costs are not primarily related to the destruction of specific equipment, but rather to maneuvers to avoid collisions.

In addition, any such maneuver will include a period of at least 24 hours during which the operation of the device is disrupted. Although such maneuvers are currently relatively rare - for example, on average once a year for the European Space Agency (ESA) remote sensing satellite Envisat - the money in this is large enough to bring about significant losses and a reduction in useful working hours. For agencies financed by taxpayers' money, this may be less of a loss.

Journey to the Solution

We reached our solution when discussing and brainstorming ideas about the problems on our orbit. We reached our solution by doing a bit of research about our orbits and their problems, when we found out that space debris is a big problem and it's a danger to people living on the orbit and our future space exploration. At first we wanted to make a "slide" that would direct the space debris into our orbit, where it would burn, but we found out that sending this huge slide into our orbit would be hard and controlling it even harder. It would also waste a lot of fuel.

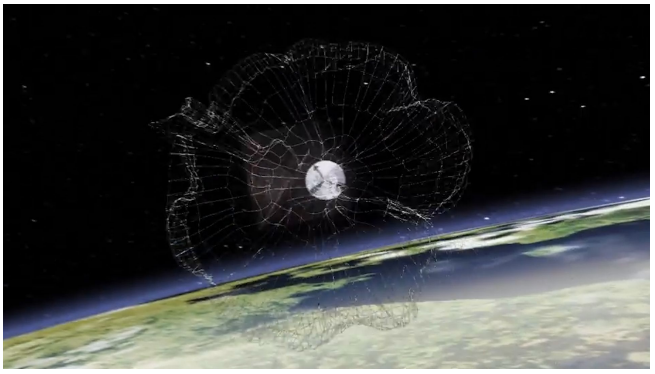
Solution

A space sponge that flies on our orbit and collects space debris that flies into it [Graphene Orbit Sponge (GSO)]. This sponge would fly with about the same speeds as space debris and it would also reach this speed, thanks to the solar wind which would bounce off from graphene and give the satellite a boost. It would collect space debris with a 30 x 30 meter mesh plate. Graphene is the 21. Century miracle material. Graphene consists of only carbon atoms in a one atom layer. Graphene is a strong, transparent, flexible and sensitive material. The combination of physical and chemical properties of graphene is extraordinary. The 1 atom layer wide material is the thinnest of the materials known so far. It has a better electric conductivity than copper and it is 100-300 times stronger than steel also its optical properties are unique.

Existing Solutions

Space debris collecting over our heads is a serious problem that has been acknowledged by all space agencies.
Recently the Japan Aerospace Exploration Agency (JAXA) tested the first space debris clearing system.

They had a 700 m fishnet like device, that was attached to the launch vehicle named Kounotori (stork in english).
SpaceX's satellite is named RemoveDEBRIS which catches space debris with a net and harpoon. This satellite is still being tested. The same kind of projects are being developed in space agencies all over the world, but the main motivation isn't cleaning space debris, but bringing back precious metal ingredients. Some of these ingredients are highly valued in the electronics industry.



A lot of the now not working satellites still have some parts on them, that could be reused for new satellites. This is what the United States of America's (USA's) Defense Advanced Research Projects Agency (DARPA) is planning with their program named Phoenix which has an objective of reusing old antennas which can be attached to the satellites in space. This solution would make sending stuff to orbit easier and satellites would also use less fuel and be lighter.
Even more ambitious is the USA's start up company Firefly Space System's (Firefly Aerospace's) plan to use the materials already on our orbit for the future Mars missions. If we are really going to create human settlements on the red planet then this project could be useful.
But it is clear that only individual companies or programs won't clear the debris. Space debris is a huge global problem, that requires global cooperation and solutions.

Feedback from Experts

Experts confirmed that space debris is an actual problem. They recommended that the device should be sent to a mother ship. Another suggestion was to bring the device to the ISS, where it would be possible to recycle the metals and other parts in it, instead of bringing the garbage to Earth, because the parts are worth nothing on Earth but in space the materials are worth a lot. It was thought that it would make more sense to make a graphene net but in fact graphene is a bit of a web-like material. The expert were a bit confused by the material.

Further Development

3D printing graphene is a new and innovative system that was made and patented just last year by Tech University and Lawrence Livermore National Laboratory (LLNL).

The device would have two 3D printers that would start printing out 2 graphene mesh plates 30x30m to either side of the device when it reaches the orbit. At first we wanted to make the graphene mesh plates on Earth and then send it to the orbit to clean debris, but a problem

appeared. When making the mesh plates on Earth it could have air bubbles that because of the pressure in space would press the graphene together. We found the possibility of printing the graphene mesh plates on our orbit, the materials to make the graphene mesh plate on our orbit would also take less room then the mesh plates and air bubbles also wouldn't occur. The device positions itself according to the signals that nearby satellites send it and it flies with the space debris to catch it.

Further development Feedback from Experts

When the device reaches the orbit two 3D printers will start printing out graphene mesh plate which are printed onto by a computer controlled bus (computing). Nearby satellites give the device information about space debris and also other nearby satellites around the device. Thanks to this the device will know if to pull in the graphene mesh plates or to turn them against the space debris to catch it.

If needed the sponges can also make a shield around ISS with space debris that would protect it from solar radiation and space debris. We were told, that its very needed and it would be a good idea to make a wheel out of the debris that would spin thanks to solar wind and it would create gravitation to the ISS which is needed for the astronauts so their health could be better.

With Who Have We Shared Our Idea?

We have shared our Project with:
Friends
Parents
Relatives
George Field - Harvard University's astronomy professor
Indrek Kolka - Estonian astronomer, University of Tartu's senior researcher
Laurits Leedjärve - Estonian astronomer, University of Tartu's senior researcher
Mari Allik - University of Tartu Old Observatory's space technology engineer
Mark Brongersma - Stanford University's professor of material science and engineering
Mart Noorma - University of Tartu's space- and defence technology profesor
Peidong Yang - Berkeley University's energetics and material science professor
Rauno Gordoni - Tallinn University of Technology MEKTORY's space center satellite program manager

Our Sources of Information

Our sources of information are the internet , research of orbits by Tallinn University of Technology (TalTech), University of Tartu (UT), University of Texas at Austin (AstriaGraph), NASA and JAXA. We also met up with a expert and watched docfilms of astronauts.

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