# On-Orbit Satellites Servicing

Satellites servicing refers to refueling and repairment of space satellites while in orbit. The decreasing cost of launching satellites and the increasing popularity of low earth orbit have made this business a very interesting perspective from the commercial point of view. The goal of this report is to introduce the exciting opportunity of this rising new sector of the space economy. In the beginning, the focus will be on the world of satellites in general, then it will shift to the main point: their regeneration in orbit. Finally, there will be a brief overview of the actual state of both the industry and the market for this new promising business.

# Satellites and Orbits

Artificial satellites have three fundamental parts: an **antenna** a **power source** and a **fuel supply**. The antenna is used for information inflows and outflows, the power source can be a solar panel or a battery, and the fuel supply, normally ethanol, is needed for changing orbits in flight or avoiding collisions with debris.

Although they come in many shapes, we can summarize satellites' functions into scientific, business, and military, while the two main features that allow you to classify them are the size and altitude of the orbit.

In terms of size, there is a lot of variability, we have very small cube satellites, which are 10 cm for less than 1 kg, as well as communication satellites that can weigh more than 1000 kg. Besides, on the largest end, we have the International Space Station, which is the same size as a field of American football.

The second criterion of classification is based on orbital altitude, and we distinguish 4 main categories of orbits:

- **Low Earth Orbit (LEO):** Located below 2,000 km of altitude, it hosts objects with a period of 128 minutes or less, thus making 11.25 revolutions per day circa. Examples of satellites in LEO are the ISS or the Hubble Space Telescope.
- **Medium Earth Orbit (MEO):** The second orbit is placed between 2,000[1] and 35,786 km above sea level, and its satellites have an orbital period <24hrs with a minimum of 2 hrs. Starting from this height all devices need special shielding against the adverse conditions of what is known as the Van Allen radiation belts, and the perturbation caused by the solar radiation pressure gets significant.
- **Geosynchronous Earth Orbit (GEO):** The third category, which is precisely at 35,768 km above sea level, hosts satellites with an orbital period equal to Earth's rotation, so one sidereal day[2]. It means that an observer from the ground will see the objects in such orbit return always to the same position in the sky every day. A particular GEO orbit is the Geostationary Equatorial Orbit, which is exactly above the equator, and it is famous because every satellite in it will appear as fixed in the sky and motionless. The main

[1] This is an arbitrary altitude chosen by convention

[2] Precisely it is equal to: 23 hrs, 56 mins, 4 s

advantage of geostationary satellites lies in the fact that they always keep the same position, and it is perfect for services like communications, weather forecasting, and navigation[3].

- **High Earth Orbit (HEO)**: Finally, there is the HEO, a residual orbit for every satellite above the geosynchronous line. In this case, the orbital period is more than one day, and because of that, satellites in such orbits will have an apparent retrograde motion. In other words, from the perspective of a ground observer, they move to the West.

## Satellites servicing (da controllare)

Every year many functional satellites that are providing weather data, communications, images from space, and other fundamental services and information are retired because they reach the end of their fuel supply. As the old satellites are moved towards the "graveyard orbit" new ones are financed, built, and launched, but this process can be highly costly and time-consuming for satellites owners and consumers. Here come in the "Satellite servicing" that allows satellites to work longer in space, and this allows to save a lot of money giving the fact that servicing a satellite is cheaper than sending in space a whole new one

"Satellite servicing" has been theoretically considered since the early days of humans attaining the capability of spaceflight, and it has been a concept since the 1960s when it became pretty clear that once a satellite was up in orbit, it was impossible to service with the technology at the time. Nearly nothing was done in the first decades and it remained a concept for academia and the very first servicing mission was for the SolarMax research satellite in 1984. Although the term is usually thought of as meaning autonomous servicing by a robotic spacecraft, actually it can also mean servicing made by humans.

As what concerns the market of satellite services, SpaceLogistics, the 2016-established subsidiary of Northrop Grumman, is one of the key pioneers in the field, providing cooperative space logistics and in-orbit satellite servicing. With its fleet of commercial servicing vehicles, also called "Mission Extension Vehicle" (MEV) is creating a line of industrious spacecraft that refuel and repair satellites and allow companies and institutions to prolong the life of their technology. Right now they have different types of vehicles, "Mission Extension Vehicle", "Mission Robotic Vehicle" that is the result of a collaboration with the U.S. Defense Advanced Research Projects Agency (DARPA), and the "Mission Extension Pod" a smaller and less expensive service vehicle that only performs orbit control.

## The industry and the market

The market of this specific sector of the space economy is still in its infancy, but there are already two other competitors to SpaceLogistics:

[3] The GPS system works thanks to satellites in this orbit.

- **Effective Space Solutions R&D Ltd. (ESS)**: founded in 2013 in Israel (and later acquired by Astroscale U.S. Inc. in 2020), which is among the first comers in the sector. It focuses on solutions for surveillance and observations satellites in LEO and geostationary communication satellites.
- **Infinite Orbis:** a Singapore/UK-based company founded in 2017 that provides different services for satellites, namely Space Situational Awareness, Autonomous collision avoidance, Satellite inspection, Life extension (up to 5 years), relocation, and Disposal to a graveyard orbit.

Given the state of the satellites industry, it can be inferred that there is a lot of potential in the market, and the segments that could be explored and further developed can be identified by either orbit category (LEO, MEO, GEO) or service needed (graveyard orbit disposal, debris protection, refueling).

The success of the Mission Extension Vehicle (MEV) can create a ripple effect and encourage startups to enter this market or established space companies to develop In Orbit Service (IOS) technologies. According to a study conducted by the Institute for Defense Analyses, both small and large space companies in the field of IOS are closely monitoring the evolutions of the sector. Furthermore, this success can stimulate the creation of additional contracts with both private and public actors, and as a result, if these contracts will be completed successfully other long-term projects will be commissioned in a virtuous cycle.

The sector of satellites servicing has already a bright future, but also the opportunity to further expand into the fields of in-orbit manufacturing and in-orbit assembly evolving into the so-called In-Orbit Operations sector. Moreover, there is a high chance that other countries like Russia, India, and China will join the competition and develop these technologies to gain independence from the other states and especially the US.

## Websites


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