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Space exploration

Introduction

In 2007 there were the celebrations for the fiftieth anniversary of the launching of the first artificial satellite, the Sputnik; and on 20 July 1969 at 9.39 p.m. (21 July at 4.56 a.m. in Italy), Neil Armstrong started slowly descending the steps of the ladder outside the lunar excursion module, or LEM.
In the mid 70s, planet Mars, our neighbour became a fundamental objective and the American mission Phoenix, that will bring a new lander to the northern polar regions of Mars, to inspect Martian soil, was launched on the 4th of August this year.
The Aurora Programme of ESA, the European Space Agency, is a long term programme to explore the Solar System that will culminate with the first human voyage to Mars in 2030 and will also see man’s return on the Moon.
The MELISSA project (Micro-Ecological Life Support System Alternative) studies exactly how, by using microorganisms and superior plants, it can be possible to reconstruct a vital cycle, that is fundamental for the survival of mankind, plants and bacteria.
The history of space exploration is a recent one that is well worth discovering.

First steps in space

First space explorations

Space exploration belongs to our recent history. In fact, 2007 marked the first fifty-year celebrations of the launch of the Sputnik , the first artificial satellite. On the 4th of October 1957, Radio Moscow announced that the USSR had successfully launched a 59 cm diameter sphere, weighing 83 kg into orbit.
For America it was a severe blow, as it was technologically inferior, and it did not have missiles that could launch objects of that weight so far.
The American reaction was soon seen: on 31 January 1958 a missile, Jupiter, of the army, designed by the German scientist Werner Von Braun, the inventor of the V2 missiles of World War II, launched the first American satellite, called Explorer 1, into orbit.
Starting from the 60s, the USSR concentrated its efforts in the design of satellites orbiting around the Earth, of the Vostok series, which culminated with the announcement, on 12 April 1961 , of the first astronaut, Major Yuri Alexievic Gagarin, to orbit the Earth. The Vostok series continued, and in particular, on 16 June 1963, Vostok 6 was the first to carry a woman on board: Valentina Tereskova.
In the meantime, starting from 1 October 1958, the Americans created the National Aeronautic and Space Administration (NASA) and started the Mercury programme, that launched astronaut Alan B. Shepard in the first suborbital flight on 5 May 1961.
On May 25 the same year, President John F. Kennedy delivered a speech, presented as a “Special Message to the Congress on Urgent National Needs”, in which he presented the Apollo programme. The part of the speech that drew the attention of the Americans most, concerned space exploration, “I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space...”.
The programme certainly involved many dangers: on 27 January 1967 during a test run on ground, a fire broke out inside Apollo 1, and all the members of the crew died. The programme was started again one year later, and continued up to Apollo 11, with Commander Neil Armstrong on board, together with pilots Michael Collins and Edwin Aldrin. At 4:57 (Italian Standard Time) on July 21, Armstrong first set foot on the surface of the moon, and uttered the famous sentence, "That's one small step for [a] man, one giant leap for mankind".
The Apollo series continued up to 1997 with Apollo 17, some missions orbited around the Moon without landing on it, others, such as Apollo 12, 14, 15, 16 and 17, instead, visited its surface.

Orbiting stations

The first concept of an artificial satellite that could accommodate human life was born from the imagination of writer, Edward Everett Hale. In his short story dated 1870, entitled “The Brick Moon”, Hale imagined he would build a space station that would orbit around the Earth, simply using some bricks.
Some time after, the literary fantasy gave room to science. In a series of articles dated 1950, the German scientist Verner Von Braun, proposed the project of a space station shaped like a wheel, that, due to its rotating movement, would allow the creation of artificial gravity within its structure. Braun’s idea inspired the American film director Stanley Kubrick in his film “2001: a space odyssey” in 1967.
However, for the theory to be put into practice, we will have to await 19 April 1971. This time it was the Russians’ turn. They were still disappointed for having lost the race to the Moon, and they successfully launched the space station Salyut 1, into orbit around the Earth.
This first type of station consisted of a single cylinder shaped module that offered very little comfort to the astronauts inside it, however it was possible to carry out experiments on the resistance, for long periods of time, of men in conditions of microgravity in the environment.
On 14 May 1973, NASA launched Skylab in space. It was 35 metres long and weighed 76 tonnes. Its internal diameter reached 6.7 metres, and therefore the available space was really enormous for its three inhabitants. Three crews alternated their stay aboard the Skylab in the period from May 1973 to February 1974.
Subsequently, in 1984, the President of the United States, Ronald Reagan, launched the project of the Space Station Freedom, a project in which also Europe with ESA, Canada and Japan were supposed to take part. Unfortunately the disaster of the Challenger (1986) forced NASA to stop, and the project was substantially slowed down. That same year, also, the USSR completed the space station Mir (Peace). It was launched on 20 February 1986 and became the most complex structure ever to be realized.
Mir was the first space station of a modular type, in other words it consisted of various structures that were launched separately and assembled in space. During the 15 year period in which it remained in orbit (in fact, it was supposed to remain in orbit for 5 years), over one hundred cosmonauts and astronauts, from at least twelve different countries, stayed aboard. It was made up of seven modules, designed so that they could be connected to the station in various manners, to adapt to the requirements of the different missions.
At the start of the 90s, the Government of the United States also involved the European Russian, Canadian and Japanese space agencies in the project of a space station. The project was presented in 1993 and the station was called Alpha. In the official documents it was then indicated as ISS (International Space Station). At present sixteen nations are involved: USA, Russia, Japan, Canada, Brazil, Belgium, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the United Kingdom.
ISS, like Mir, is a modular satellite that rotates around the Earth on a low orbit at an average height of 400 km, just above the denser layers of the atmosphere. It completes an orbit in approximately 90 minutes, and it is inclined more than 50 degrees on the equator, that is defined so that ISS can be reached from the launching bases of almost all the space areas in the world.
The International Space Station is a large scientific laboratory, and it includes one European laboratory, the Columbus, two American laboratories, one Japanese and three Russian laboratories. Here new technologies are experimented, that may be used again for space applications in the future or may turn out to be useful on the Earth to improve everyday life.

Exploring the Red Planet

In the mid 70s planet Mars, our neighbour, became a fundamental target for two American probes: the Viking twins. Both the orbiter module and the lander module took the first detailed photographs of the surface of Mars, and generated a map of over 90% of the planet . The public image of Mars changed brusquely: the red planet was no longer luxuriant nor did it have a rich vegetation, rather, it was similar to the Earth’s tundra region, a desert area with no signs of life.
The estimated duration of the mission was 90 days starting from the time of landing, but both the lander and the orbiter continued to operate well after the estimated term. The mission was declared over on 21 May 1983, more than 6 and a

half years after the date that was initially estimated by the module designers.
Subsequently, exploration of Mars was substantially paused for over twenty years, a period of time that was interrupted only by the American Mars Global Surveyor mission, launched in 1996, that started sending the first images of the Red Planet at the end of '97. Its high resolution images made it possible to also appreciate the details of the planet, and for the first time it was hypothesized that water might be present on the planet.
From this time onwards the search for water, be it on the surface or trapped in the form of ice or in the subsoil in the form of permafrost, became the main aim of all the missions to the Red Planet.
In 2001, in fact, the American probe Mars Odyssey, managed to discover large quantities of hydrogen just below the surface, a clear clue of the presence of water.
However 2003 was the year of a peak in the missions to Mars, with the clear aim to "reveal" the water that apparently seems to have disappeared, but which probably is to be found in the layers of the subsoil. The European probe Mars Express was launched, and it transported the rover Beagle 2 and two NASA rovers, Spirit and Opportunity. 2003 was a propitious time for exploration of the Red Planet as Mars and the Earth were in a particularly favourable orbit configuration, called the Great Opposition. In fact, at the end of August, due to the elliptical shape of their orbits, the two planets were at their closest approach point, at a distance of only 56 million km.
The orbiter entered the Mars' orbit on 25 December 2003, and on the same day the rover Beagle 2 was unhooked. After repeated attempts to communicate with it, on 6 February 2004 the rover was declared lost, probably it was destroyed on impact with the atmosphere.
The first image of the Orbiter showed Valles Marineris, with such a level of detail that had never been reached before. In the two following years, the images sent to the Earth provided the first direct proof of the presence of water on Mars.
Finally, on 4 August this year, the American mission Phoenix was launched, which will carry a new lander to the polar regions of the north of Mars, to inspect Martian soil in search of proof of the existence of past or present life. Phoenix shall study the climate and the geology of Mars to prepare for the mission of human exploration on the Red Planet.
Peter Smith, researcher at the University of Arizona, in Tucson, has said that Phoenix will enable us to explore the regions of the Northern hemisphere of Mars, where the environmental conditions are similar to those of the Earth.
In fact, thanks to a mechanical arm, Phoenix shall be able to probe the frozen layers of Mars and take samples to be analyzed. In a certain sense, Phoenix shall try to give a final answer to the fundamental queries of NASA's long programme of exploration on Mars : was there life on Mars in the past?

Space Missions

Three…two…one…go!

How is a probe launched into space? In order to succeed in sending any object into space, or even simply making it orbit around the Earth, it must be given a thrust that can lift it off the ground, and accelerate it up to a speed of approximately 36000 km/h, about 40 times the speed of the airlines' aircraft. For this purpose, special rockets known as launchers are used. These release a thrust that is sufficient to win their own weight. The technique is very simple: the gas, produced by combustion of the so-called propellant in the engine, is expelled at a speed of approximately 16000 km/h downwards, and in turn, due to the recoil, the rocket is pushed upwards. Obviously in order to produce such a thrust, a very large amount of gas must be expelled, and therefore many dozens of tonnes of propellant must be used. The more propellant is burnt, the greater the thrust that is generated, but at the same time the total load to be lifted and transported to the higher altitudes increases. It must not be forgotten that not only the satellite needs to be lifted but the entire structure, including the tanks full of propellant.
For example, the European launcher Ariane 5 can lift off and put a satellite that weighs approximately 6 tonnes into orbit. But the total mass of Ariane 5 is 750 tonnes, 120 times greater than its pay load!
It is possible to avoid this problem of the load, allowing a greater weight, by simply choosing the area where the rocket will be launched carefully. In fact, not all the locations on the Earth are equivalent. Our planet behaves like a top that spins around itself in approximately 24 hours, and since it is not a perfect sphere, places at different latitudes travel

around a circumference that increases progressively as we move from the poles to the equator. And since all the points of the Earth take the same amount of time to complete a full circle, a point that is on the equator will move at a greater speed.
So the solution has been found: if the launch takes place on the equator, the Earth's rotation shall behave just like a sling, thus a large amount of fuel is saved.

Assisted by gravity

The heavier probes, that must face long trips, heading towards planets that are beyond the Solar System, are launched with enormous slingshots. This technique, that was developed in the years 1961-63, by the mathematician Michael Minovitch, is called Gravity Assist.
In order to better understand what it is, we must once again examine the history of the Cassini-Huygens probe that reached the giant Saturn in 2004, after a journey that lasted seven whole years. To date in fact there are no launchers that can send a 6 tonne probe, equivalent to a bus that can carry 30 passengers, directly to Saturn. In order to reach it in fact, the probe must have an average speed of 50 km/sec. which is quite different from the 5 km/sec at which it is launched. For this mission, therefore, a particular technique was adopted, which in fact, has been named Gravity Assist, that exploits the mutual gravitational attraction of the planet and the probe, in which the planet acts as a slingshot that accelerates the probe.
The Cassini Huygens mission used this natural propulsion four times: on 26 April 1998, and 24 June 1999, Venus provided the first two gravity assists, then it was provided by the Earth on 18 August 1999, and finally by Jupiter on 30 December 2000.
Just to have an idea of the result of a gravity assist, in the case of Venus the couple of probes increased the speed of the module approximately 15 times, from 5 km/s to 75 km/s, while the speed of Venus decreased by 2×10^{-20} km/s, i.e. it remained practically unvaried. The different collisions with the planets are therefore necessary to change the speed of the module and to change the probe's flight path, to guide it towards the desired route.

The Aurora programme

The Aurora Programme of the European Space Agency (ESA) is a long-term programme to explore the Solar System, that will culminate with the first human voyage to Mars in 2030 and will also see man return on the Moon. On parallel lines the presence of life in the Solar System will be sought, in fact most of the missions of the programme shall carry sophisticated instruments that are able to detect even the smallest biological traces.
In the first phase of the programme the first robotic missions will be launched, and developed and tested technologies to support life on an extraterrestrial planet.
At a later date, the foundations shall be laid for astronauts to land on the Moon, where the technologies for the next human expedition to Mars that is scheduled in the third and last phase of the programme, shall be tested in-situ.
The first problem to be faced will be the development of air and water recycling systems and later on, the extraction of resources, directly from the planet the spacecraft lands on.
For example, on the Moon, oxygen could be extracted from minerals, while on Mars from the carbon oxide.
However, even before thinking of exploiting the resources of a planet for human survival, it will be necessary to solve the problem of the long time spent in space for the long range space journeys . It is certainly not imaginable to take all the material that is necessary for survival from home. For example a crew of 6 people travelling for 3 years to Mars would require a load of 33 tonnes, plus the waste materials. It will be necessary to develop technologies that enable the recycling of the fundamental elements for the life of waste materials.
The MELISSA (Micro-Ecological Life Support System Alternative) project studies just how, using micro-organisms and superior plants, it is possible to re-create a vital cycle that is fundamental for the survival of human life, plants and bacteria.
MELISSA is a laboratory composed of five compartments dedicated to specific functions, colonized by thermophilic

anoxygenic bacteria, photohererotrophic bacteria, photosynthetic bacteria and higher plants (barley, potatoes, soya, spinach, lettuce and onions).

Titan and the primordial "soup"

The Cassini-Huygens probe, a project in which ESA and NASA collaborated, left in 1997 heading for Saturn, one of the giants of the external Solar System. After a journey of seven long years, finally it reached its destination, Saturn - Lord of the rings, on first July 2004. The mission consisted in entering Saturn's orbit and releasing, on 25 December of the same year, the Huygens module, which would have descended on the surface of the satellite Titan with the help of a parachute.
Why Titan? Titan is Saturn's largest satellite, and in fact it is the only moon of the Solar System that has an atmosphere and scientists believe it is very similar to that of the Earth, before life appeared. Below the atmosphere it is believed that there are oceans of liquid methane and ethane, under a frozen surface.
Titan is the esobiological site par-excellence, of the entire Solar System. A small miniature Earth at the time the first organic molecules appeared, that became the precursors of life on our planet.
In fact the external part of the Solar System, where also Saturn and its satellites are to be found, is the most ancient part of the Solar System and has maintained most of its initial conditions, following the formation of the Sun and the planets. The internal part instead is inhabited by smaller planets, with higher temperatures, whose atmospheres have cancelled many traces of the primordial evolutive phase, preventing us from understanding the chemical and physical course that led to the appearance of life. In the external part of the Solar System, where temperatures are remarkably lower, it is possible to follow these processes directly, as if we were taking a trip back in time, to the beginning of the history of the Earth

Biolab: a project European

At the beginning of December 2007, the European laboratory Columbus left the Kennedy Space Center heading towards the International Space Station. A large amount of the usable space, equivalent to 75 m3, was stacked with special racks, and had real research laboratories, in different fields: the European Transport Carrier (ETC), the Fluid Science Laboratory (FSL) the European Physiology Modules (EPM), the European Drawer Rack (EDR) and the famous Biolab.
Biolab is a minilaboratory which occupies a volume of 2 m^3, that will be utilized by the astronauts to carry out studies on the different behaviour and different growth, in the presence of microgravity, of microorganisms, cells, bacteria, small plants and small invertebrates. It is subdivided into two parts: on the left, a completely automatic section, where the experiments are carried out; on the right, the manual section, used solely to stock the samples and for specific manual activities of the crew.The most interesting part of the Biolab is the incubator, a device that can keep the environment at a constant temperature between 18 and 40 degrees centigrade. Furthermore, inside the incubator, there are two centrifuges with six Experiment Containers each, in which the microorganisms to be studied are introduced, and which can, independently one from the other, simulate the Earth's force of gravity. Gravity is obtained by making the Containers rotate on a disc where they are made to reach a speed that gives place to a centrifugal force of 1 g, which is equivalent to the Earth's force of gravity.