

## 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  $2 \times 10^{-20}$  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, photoheterotrophic 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 m<sup>3</sup>, 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<sup>3</sup>, 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.