MOON, MARS & BEYOND

Vision For Space Exploration

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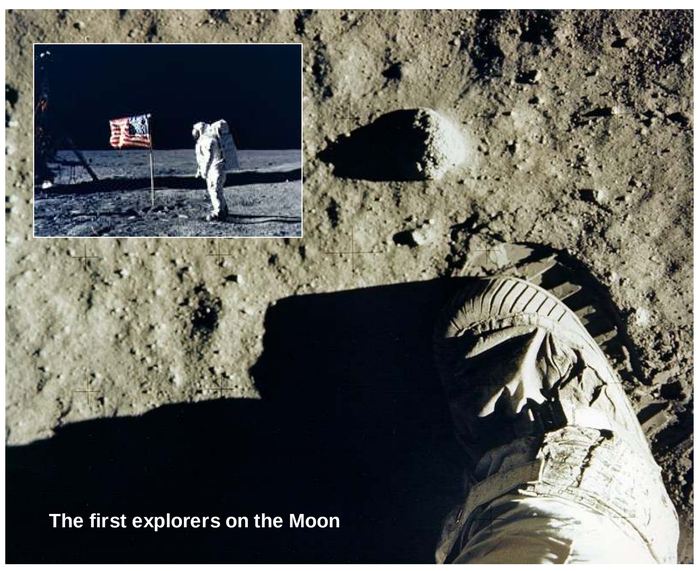
www.jpl.nasa.gov/earth/

On July 20, 1969, the human race accomplished its to date single greatest technological achievement of all time, when a human first set foot on another celestial body, and described the lunar surface to an audience of millions back on Earth as being like powdered charcoal. Experts of the day predicted that with this event Mankind was well launched upon the exploration of space, envisaging permanent research stations, if not actual settlements, on the Moon by the year 2000. History has shown that this forecast was over-optimistic, and - after only six landings on Earth's only natural satellite (the last one on April 21, 1972) - manned space flight was again reduced to Low Earth Orbit missions.

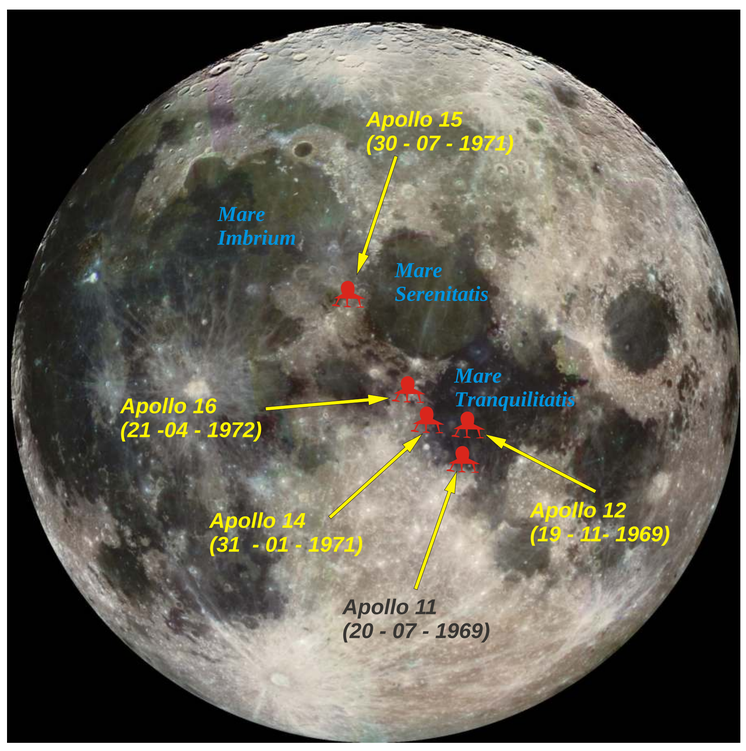
The Apollo Programme

As a child of the "Cold War" age, *Apollo* was more about national prestige and advantage (popularly referred to as "flags and footprints") than it was about science. Although an exciting project that opened up new horizons for all Mankind, scientific returns were limited, and its military connotation was evident in the fact that all the early astronauts were test pilots from one of the services without formal scientific training.

Between them the various *Apollo* missions brought back 382 kilogrammes of lunar rocks, core samples, pebbles, sand and dust from the various exploration sites (right). The larger part of the *Apollo* material is still housed at the Johnson Space Center in Houston, Texas, from where these pristine lunar samples continue to be shipped to scientists and educators all over the world for research and teaching purposes. In this way, nearly 1000 samples are distributed each year.



The first explorers on the Moon

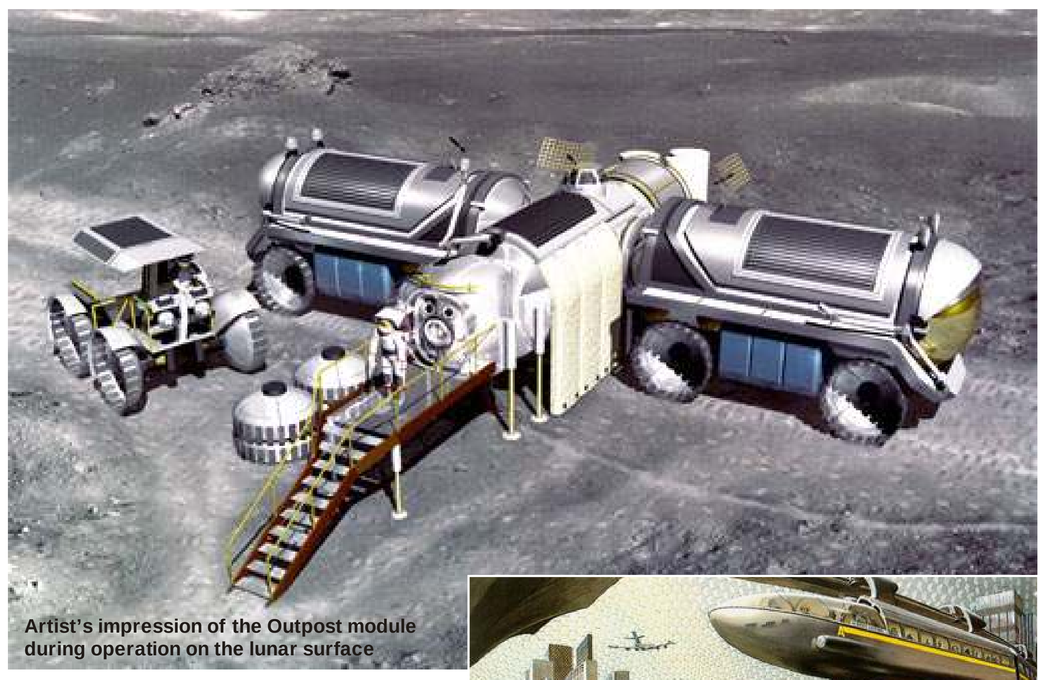


The study of lunar rock and soil samples obtained by *Apollo* has yielded useful information about the early history of Moon, Earth, and the inner solar system. Computer models indicate that the Moon probably has formed from the debris resulting from the Earth being struck a glancing blow by a planetary body about the size of Mars - a theory that is compatible with the chemical composition of the analysed lunar rocks. The rock and soil samples provide a record of the formation of a lunar crust ca. 4.4 billion years ago, and the intense meteorite bombardment and lava outpourings that followed it. Trapped in the Moon's crust, radiation spewed out by the Sun since its formation, in addition bears witness to the activity of our central star over the eons.

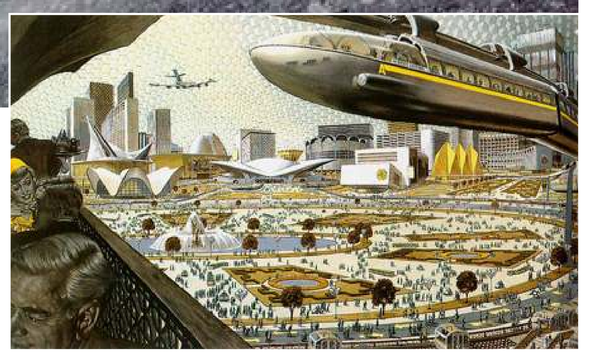
Living on the Moon

Nearly 50 years after the end of the Apollo programme, humans are scheduled to return to the Moon before the end of the next decade... and this time they mean to stay! Future lunar excursions will be of much longer duration than the original ones, which lasted no more than a few hours, but to survive any length of time in this hostile environment suitable living quarters have to be constructed for the explorers. Currently researchers in tandem with industry are developing various types of lunar habitation systems (below), such as the *Sortie* and *Outpost* modules, which are designed for brief and extended stays on the lunar surface, respectively (in Earth-terms this would be comparable to weekend camping trips with backpacks and month-long expeditions in well-equipped mobile homes). Apart from featuring greater amenities for the crew, the bigger *Outpost* habitat will also be able to accommodate a certain amount of laboratory equipment, allowing in depth scientific surface studies, technology demonstrations, as well as the testing of operational techniques *in situ*.

Model of an inflatable lunar habitat and airlock unit (sortie module) at one of the test and research centres



Artist's impression of the Outpost module during operation on the lunar surface



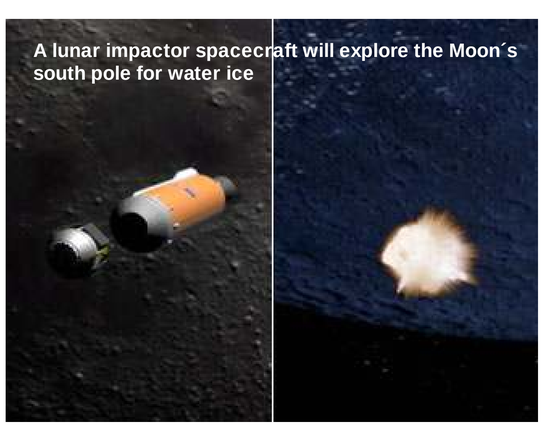
Fictional city on a "terraformed" planet

The Way Back

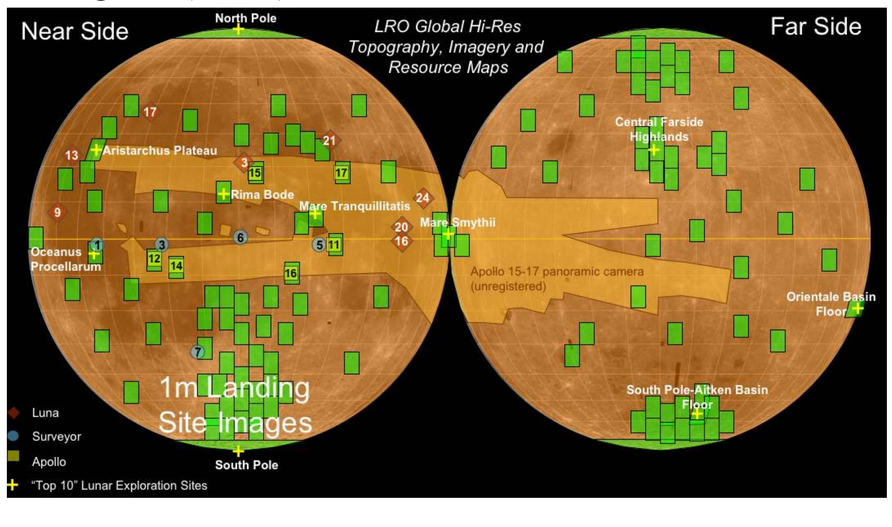
After the end of the "space race" between the United States of America and the former Soviet Union, questions were raised not about space exploration in general, but about the cost effectiveness of sending humans into space. The necessity to devise adequate life support systems for a crew multiplies the expense of any space mission enormously, and it was argued that robotic probes can collect the same or better data at a fraction of the outlay (e.g. *Mars Rovers*, *Stardust*).

The "Vision for Space Exploration", announced by American president Bush in January 2004, now calls for returning humans to the Moon by 2020. However, as technology has advanced with giant steps during the past forty years, so the awareness of problems to be encountered by humans on the lunar surface has also grown, and before landing civilians in this hostile environment a number of robotic trial missions are planned by NASA between 2008 and 2016. Apart from providing better maps of the lunar topography, they will study the radiation environment, explore the availability of exploitable resources, like water, oxygen, hydrogen and metals, as well as assess the very real danger from meteorite impacts to future explorers, since the the Moon has no protective atmosphere like Earth. As the first of these preparatory missions the *Lunar Reconnaissance Orbiter*, which will make a detailed survey of the lunar surface to help determine possible landing sites (below), is scheduled for launch in October 2008.

From 2008 the Lunar Reconnaissance Orbiter (LRO) will chart the lunar surface in detail



A lunar impactor spacecraft will explore the Moon´s south pole for water ice



In terms of logistics, a re-usable *Crew Exploration Vehicle*, including suitable launch systems, which will build on the best of *Shuttle* and *Apollo* technology, is currently being developed and tested at the various NASA centres across the United States. This will replace the more than 100 metre tall non-re-usable *Apollo/Saturn V* assembly of the early 1970s, whose enormous cost would be prohibitive for building and maintaining a permanent base on the lunar surface.

...And Beyond

Having gained a foothold on the Moon, Mars will be the next logical step in manned space exploration. Already our neighbouring planet - at closest approach a mere 60 million km distant from Earth - has been investigated by a number of orbiting and landing probes (Mars Reconnaissance Orbiter, Mars Rovers), whose wealth of data have given scientists a fairly good idea of conditions on the red planet. In contrast to the Moon, Mars has the remnants of an atmosphere, and - due to its greater mass - a higher gravity, but in other respects conditions are very similar, e.g. significant temperature differences between night and day. Accordingly the establishment of a permanent lunar base will be a good preparation for the eventual journey to Mars that Mankind no doubt will undertake before too long... even if domed in cities or a "terraformed" Mars (above) for some time to come will remain confined between the covers of popular science fiction literature.