

# Past and current developments in human flight operations for planetary exploration.

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## Abstract

Human exploration of the Moon and Mars was the original objective of the nineteenth and twentieth century aeronautics pioneers. The APOLLO programme constitutes until now the only demonstration of the benefits of human direct intervention in a planetary mission.

## 1. APOLLO and past projects.

The original objective of APOLLO was “of landing a man on the Moon and returning him safely to the Earth”. The science objectives came later and this paper describes how they could be accomplished through operation progresses between APOLLO 11 and APOLLO 17. An interesting second program was the ANTEUS project which was designed in 1978 to resolve the issues that the VIKING mission to Mars had left open and which did not go beyond a NASA study.

### 1.1 APOLLO

APOLLO science was present both on the moon and in orbit through various cameras. EVA's had to be performed to recover film cartridges from the APOLLO service module. On the surface, science operations were shared between the ALSEP (APOLLO lunar surface experiment package) and rock collection managed on the model of field geology. All these activities were extremely crew dependent as computer assistance was at its beginnings and proved itself even insufficient for landing the Lunar Exploration Modules, these had to be piloted. Science operations were not separate from ground control but their analysis after each mission led to a steady increase of the science return of the missions.

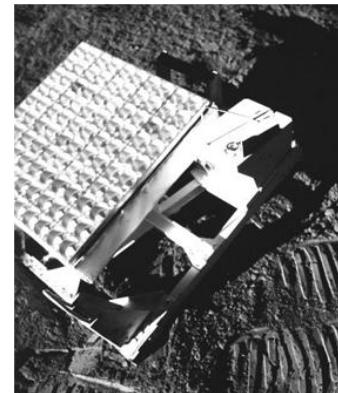


Figure 1: ALSEP retro-reflector installed by the astronauts, using a bubble level and a gnomon with a pre-computed shadow abacus. (NASA document).



Figure 2: Apollo 17 astronaut Harrison Schmitt during his lunar field trip (NASA document).

This presentation details the successes and failures encountered.

## 1.1 ANTEUS

ANTEUS was a Mars sample return mission designed in 1978 where the samples were quarantined from the earth on a space station composed of elements of the SPACELAB programme, human participation was there also extremely important.

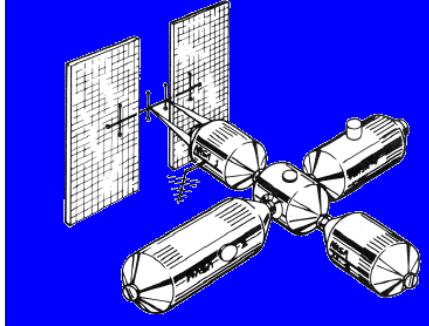


Figure 3: The ANTEUS space station for the receiving and processing of Mars samples. (NASA drawing).

## 2. Current developments.

Since the interruption of the APOLLO Moon programme human flight science was conducted from various low orbiting platforms: SKYLAB, SALIUT, the space shuttle, SPACELAB, MIR and the present International Space Station. Exploration was secondary compared to microgravity research and earth observations. The study of the physiology of long flights was the closest exploration related objective of this period.

Two recent changes put again the exploration at the heart of manned flight. First, astrobiology studies on the external parts of the space station represented by the EXPOSE package (for example, Raggio et al, 2011) as well as space studies of Mars analogues. Secondly, new technological developments are tests of robotic equipment that will be part of the future complement of tools necessary for the operation of manned planetary exploration. One specific example is the METERON robot project, this robot command network is managed from the International Space Station by the astronauts and simulates commanded operations on a planetary surface. (Bosquillon de Frescherville et al, 2011). The intent is to have more agile operations than with robots commanded from the earth. METERON involves NASA, ESA,

ROSCOSMOS and DLR. Currently, B.USOC manages the METERON operations on the ISS as Facility Responsible Centre. Another example is the “Robotic Refueling Module (RRM)” put forward by NASA and CSA and developing fresh satellite-servicing technologies which can be used either during the cruise to the planets or during surface operations.

In a similar manner, NASA is testing novel electric propulsion techniques using Hall effect which could reduce the transfer time to planetary targets.

## 6. Summary and Conclusions

Manned space exploration, which had seemed to outsiders to consist of repetitive expansive operations in low earth orbit knows now a revival and leads to exciting developments approaching the large expansion begun fifty years ago in the first years of the APOLLO project. There are signs that the current NASA reflection on the evolution of the exploration programme will put again man at the centre of its preoccupations, this possibility should not be overlooked in Europe.

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